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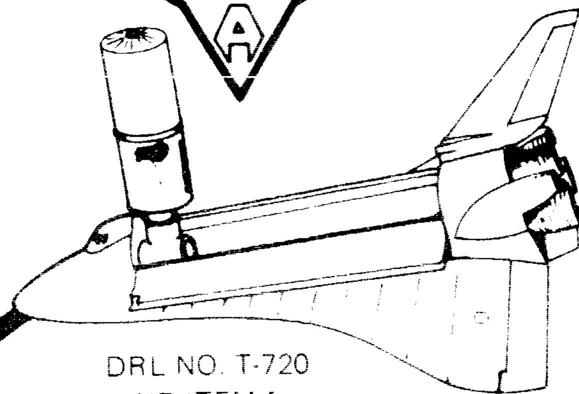


DRL NO. T-720
LINE ITEM 1
DRD: MA-182T
REPORT NO. T-192-RP05
CONTRACT NAS9-12507

study of space shuttle eva/iva support requirements

VOLUME V
REQUIREMENTS STUDY FOR SPACE SHUTTLE EMERGENCY IV SUPPORT

30 APRIL 1973

VOUGHT SYSTEMS DIVISION

STUDY OF SPACE SHUTTLE

EVA/IVA SUPPORT REQUIREMENTS

VOLUME V

REQUIREMENTS STUDY FOR SPACE SHUTTLE
EMERGENCY IV SUPPORT

REPORT NO. T-192-RP05

30 APRIL 1973

Prepared by:

R. J. Copeland
R. J. Copeland
ECS Systems

R L Cox
R. L. Cox
Project Engineer

Submitted To

NASA-Johnson Spacecraft Center
Under
Contract No. NAS9-12507

Vought Systems Division
LTV Aerospace Corporation
P.O. Box 5907
Dallas, Texas 75222

Approved by:

R. J. French
R. J. French
ECS Systems

PREFACE

This document is submitted by the Vought Systems Division, LTV Aerospace Corporation, P.O. Box 5907, Dallas, Texas 75222, to the National Aeronautics and Space Administration, Johnson Spacecraft Center (JSC), Houston, Texas, in accordance with Contract No. NAS9-12507, dated 28 March 1972. It is the Final Requirements Study for Space Shuttle Emergency IV Support Report, and fulfills part of the requirements of DRL No. T-720, Line Item 1, DRD MA-182-T. It contains final detailed documentation on Work Breakdown Structure Subtask 1.6, Emergency IV Support Requirements. The following additional volumes complete the final documentation.

Volume I - TECHNICAL SUMMARY REPORT

Volume II - EVA/IVA TASKS, GUIDELINES, AND CONSTRAINTS DEFINITION

Volume III - REQUIREMENTS STUDY FOR SPACE SHUTTLE PRESSURE SUITS

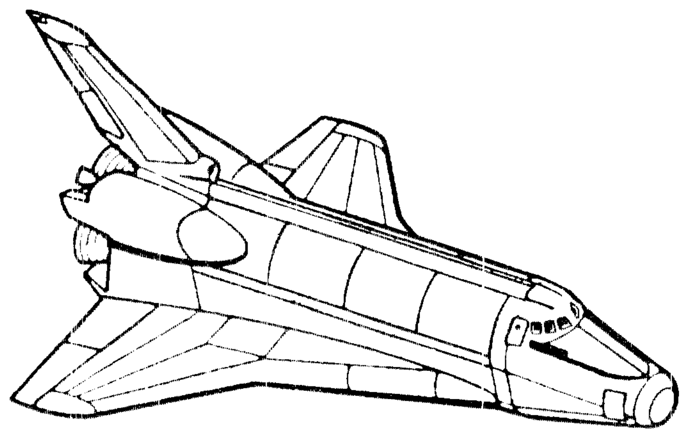
Volume IV - REQUIREMENTS STUDY FOR SPACE SHUTTLE MOBILITY AIDS

A special task on the 10 psia Orbiter Cabin Impacts, plus a delta-task on Emergency IV Requirements, were conducted for NASA subsequent to the completion of basic contract work. This was accomplished by agreement between the Technical Monitor, Mr. D. L. Boyston of NASA-JSC, and the VSD Project Engineer, Dr. R. L. Cox. In this connection, the detail of final documentation was relieved, and Volumes I, II, and IV are largely updates of briefing material previously presented to NASA. This volume, therefore, basically consists of a briefing entitled "Space Shuttle Emergencies", given at NASA-JSC on 5 April 1973, and a "Supplementary Briefing Emergencies", given at NASA-JSC on 13 March 1973. Both are updated.

Work on this contract was conducted over the time period 20 March 1972 through 30 April 1973.

CONTENTS

SPACE SHUTTLE EMERGENCIES

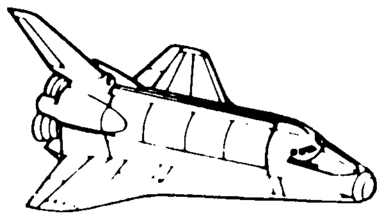


BRIEFING TO
NASA-JSC
APRIL 1973
REVISED

This briefing contains the results of a delta-task conducted for NASA subsequent to completion of the basic effort under Contract NAS9-12507. The briefing was initially given at NASA-JSC on 5 April 1973. A number of revisions have been made since that time, and are incorporated in this revised version. Revised pages are so marked.

OBJECTIVES

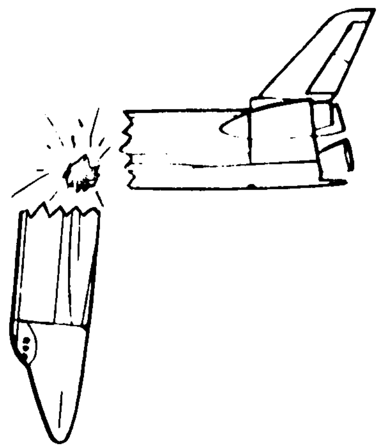
BASELINES

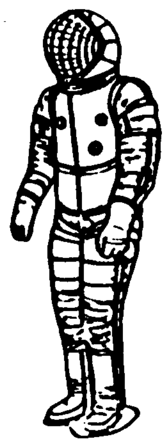


EMERGENCIES

CAUSES

OPTIONS





IMPACTS

RECOMMENDATIONS

ORBITER BASELINE

150K ORBITER

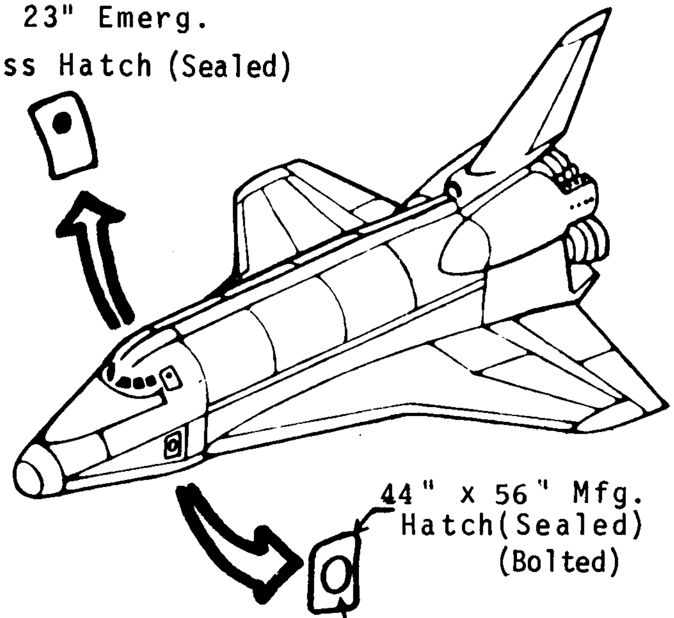
- 20" SHORTENED CABIN (2000 ft^3)
- 63" dia x 82" AIRLOCK (144 ft^3)
- DOCKING MODULE CARRY-ON

EMERGENCY RE-ENTRY

- 95 MIN PANIC MODE (WORLDWIDE AIRFIELDS)
- 165 MIN QUICK RETURN (8 US BASES)
- 285 MIN QUICK SAFE RET. (5 US BASES)
- 810 MIN PLANNED RETURN (3 US BASES)

DEPRESSURIZED CABIN

- CANNOT REENTER UNPRESSURIZED
- MANIPULATOR CANNOT FUNCTION UNPRESSURIZED
- CANNOT STABILIZE ON-ORBIT UNPRESSURIZED
- EMERGENCY AVIONICS OPERABLE TO APPROXIMATELY 8 PSIA
- STRUCTURAL CABIN ΔP MAX. OF 0.5-1.5 PSI INWARD



NOTE: HATCHES MUST BE SEALED PRIOR TO RE-ENTRY

Rev.

BASELINE ORBITER EMERGENCY SYSTEMS

FLOOD FLOW

- UP TO 150 pph CABIN PRESSURE MAKEUP FOR ONE HOUR, AUTOMATIC ON LOW CABIN PRESSURE (APPROX. 14 PSIA)
  - — 100 lb EMERGENCY 3000 psi N_2
  - — 50 lb EMERGENCY 3000 psi O_2
  - — 15 pph CRYOGENIC O_2
- ATTEMPTS TO MAINTAIN 14.7 $\pm$ .2 PSIA CABIN, 3.1 $\pm$ .1 PSIA OXYGEN PARTIAL (N_2 MAKEUP SHUTS OFF WHEN P_{O_2} FALLS TO 3.0, STAYS OFF UNTIL P_{O_2} REACHES 3.2)
- 150 pph PURGE FLOW POSSIBLE BY MANUAL ACTUATION OF RELIEF VALVE

AIRLOCK

- CARRY-ON 15 SECOND EMERGENCY AIRLOCK REPRESSURIZATION TO 3.25 PSIA
- AIRLOCK PURGE CAPABILITY (MANUAL ACTUATION DEPRESS/REPRESS VALVES)

C & W

- FIRE, CABIN TOTAL PRESSURE, O_2 AND CO_2 PARTIAL PRESSURE, CABIN FLUID LOOP TEMPERATURE, HIGH O_2 AND N_2 FLOW

OXYGEN MASKS

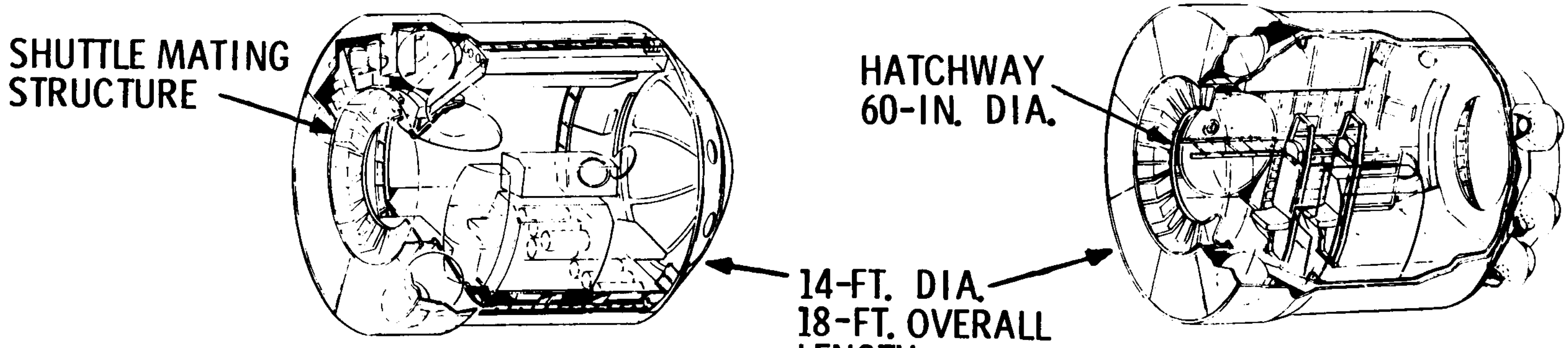
- 4 FACE MASKS - 10 MINUTE 900 PSIG PORTABLE O_2 - PLUG-IN TO VEHICLE OPERATION OR RECHARGE

FIRE CONTROL

- 4 PORTABLE FOAM FIRE EXTINGUISHERS
- CONTINUOUS 1 lb/DAY OVERBOARD PURGE OF AVIONICS BAY; BAY MAINTAINED 0.4 PSI BELOW CABIN BY SUPPLY VIA RELIEF VALVE
- AUTOMATIC 6% FREON 13B1 FLOOD IN AVIONICS BAYS

Rev.

BASELINE SORTIE LAB (RAM)

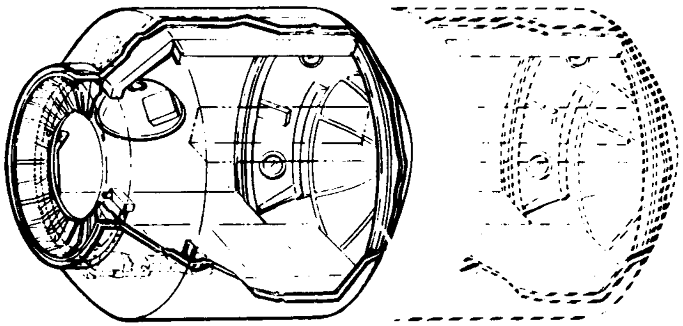


SORTIE RAM

RAM SUPPORT MODULE

PHYSICAL

- RAM REPRESENTATIVE OF SORTIE LAB
- SORTIE LAB LENGTH 25-1/2 FT.
- 18 & 32 FT RAM'S CAN BE COMBINED
- RAM TOTAL PRESSURIZED VOLUMES OF 1900 AND 3900 FT^3
- SINGLE EGRESS PATH THROUGH FWD HATCH



RAM PAYLOAD MODULE (18-FT. & 32-FT.)

BASELINE SORTIE LAB EMERGENCY SYSTEMS (RAM)

REPRESSURIZATION

- VALVES AND CONSUMABLES FOR ONE DEPRESS/REPRESS

SUITS

- 8 PSI SUITS AND PURGE O_2/N_2 SUIT LOOP (6 HOURS)
- 10 FT AND 30 FT UMBILICALS

FACE MASKS

- 45 MINUTE PORTABLE O_2
- PLUG-IN O_2/N_2 FROM ECLSS

C & W

- FIRE; RAPID PRESSURE DECAY; CONTAMINATION; O_2, N_2, AND CO_2 PARTIAL PRESSURES; FREON LOOP TEMPERATURE, ETC.

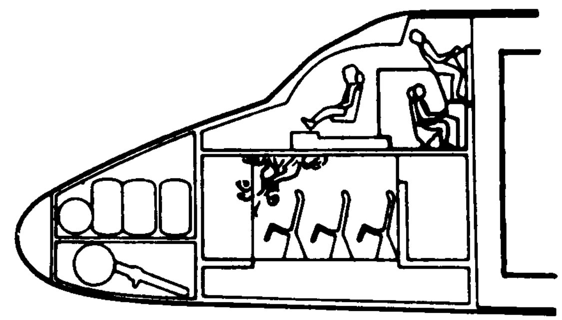
FIRE CONTROL

- PORTABLE FOAM FIRE EXTINGUISHER
- PORTABLE LIGHT

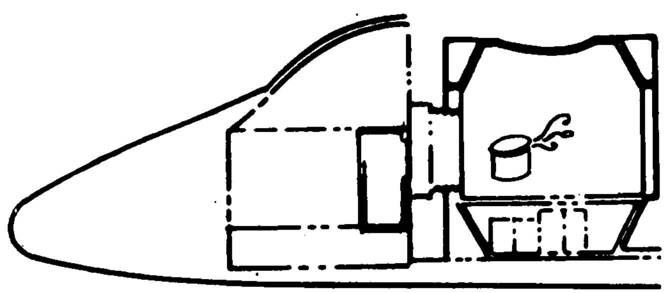
POTENTIAL EMERGENCIES

- CONTAMINATED ATMOSPHERE
- ACCIDENTAL DECOMPRESSION
- INABILITY TO RE-ENTER
- CREWMAN STRANDED

CONTAMINATED ATMOSPHERE



ORBITER CABIN

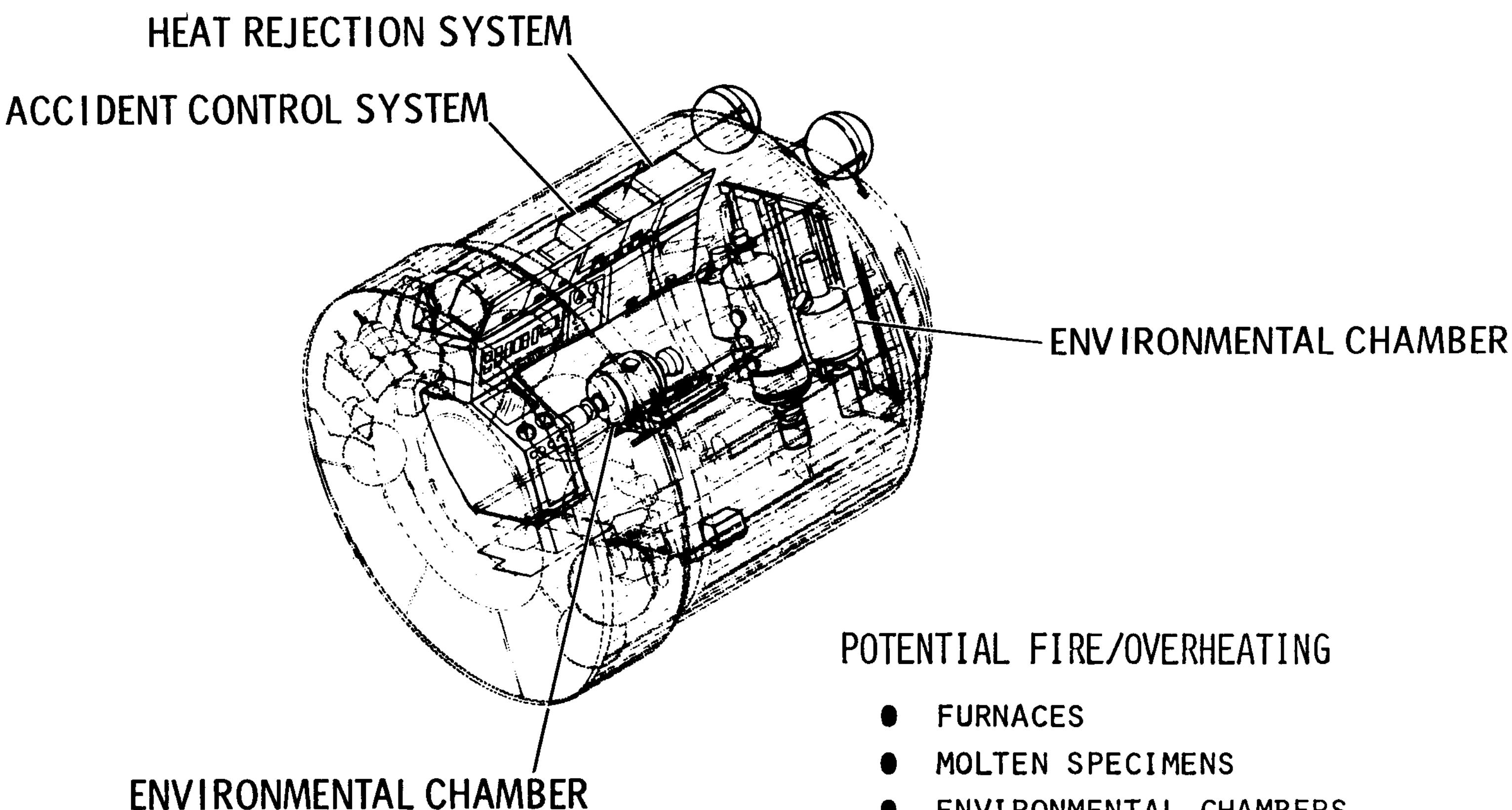


MANNED EXPERIMENT MODULE

CAUSES

- FIRE
- EQUIPMENT OVERHEATING
- EXPERIMENTAL MATERIALS

MATERIALS SCIENCE SORTIE EXAMPLE
CONTAMINATED ATMOSPHERE



POTENTIAL FIRE/OVERHEATING

- FURNACES
- MOLTEN SPECIMENS
- ENVIRONMENTAL CHAMBERS

OCT. 1972 NASA-JSC TRAFFIC MODEL (225 FLIGHTS) SIMILAR SORTIES:

- 10 MATERIALS SCIENCE/ADVANCED TECHNOLOGY
- 20 ASTRONOMY/PHYSICS
- 5 LIFE SCIENCE

Rev.

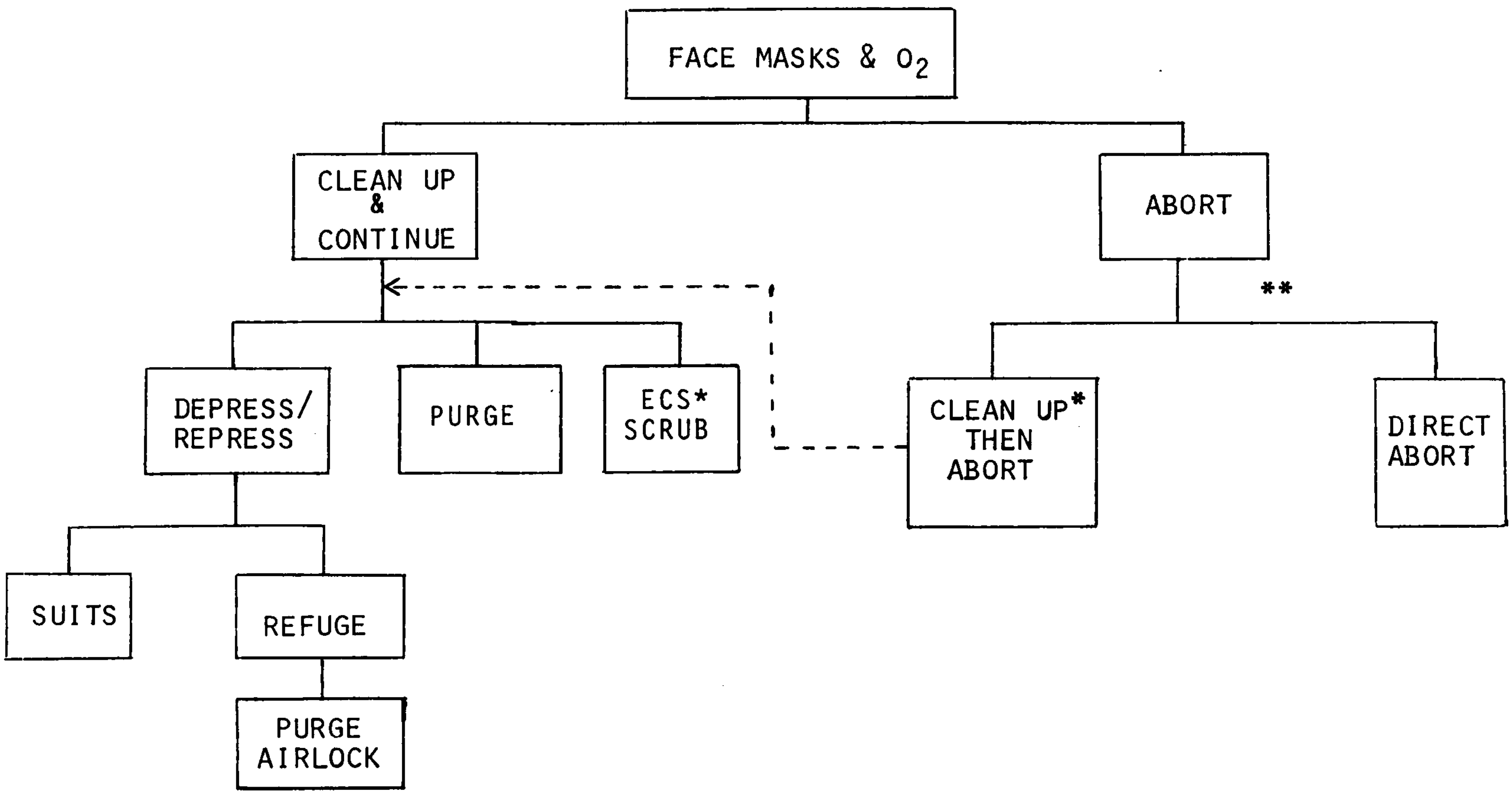
HAZARDOUS EXPERIMENT AND SERVICING FLUIDS

FLUID	NUMBER OF VARITIES IDENTIFIED	EXAMPLES	HAZARD			
			TOXICITY	FIRE	CORROSIVE	EXPLOSIVE
CRYOGENICS	11	LH_2, LN_2, LO_2, LH_E, SUPERFLUID HELIUM, ETC.	X	X	X	X
GASES	16	CO, CO_2, NO, X_E, CH_4, PROPANE, ETC.	X	X	X	X
LIQUIDS	27	N_2H_4, FREONS, SOLVENTS, LIQ. METALS, ETC.	X	X	X	X

- BASED ON "SAFETY IN EARTH ORBIT", NR SD72-SA-0094-2, JULY 12, 1972
- OCTOBER 1972 NASA-JSC TRAFFIC MODEL : 56 SORTIE FLIGHTS, 27 SERVICING FLIGHTS, 225 TOTAL FLIGHTS

Rev.

VIABLE CONTAMINATED CABIN OPTIONS

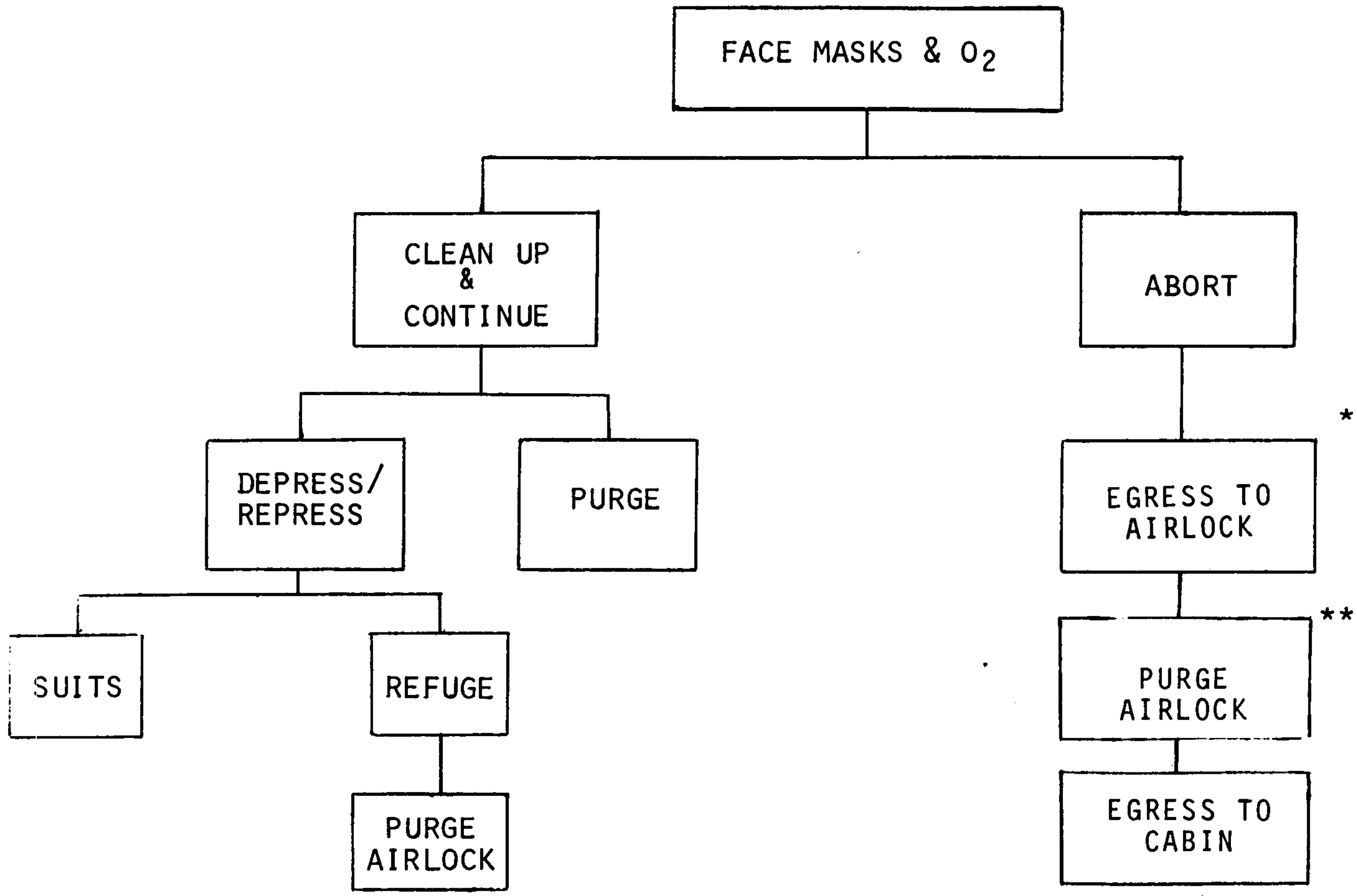


* MAY BE REQUIRED FOR VISIBILITY; ECS SCRUB VIABLE OPTION TO CLEAR SMOKE

** REFUGE AND WAIT FOR ON-ORBIT RESCUE
NOT CONSIDERED VIABLE OPTION FOR CONTAMINATED ATMOSPHERE

Rev.

VIABLE CONTAMINATED SORTIE LAB OPTIONS

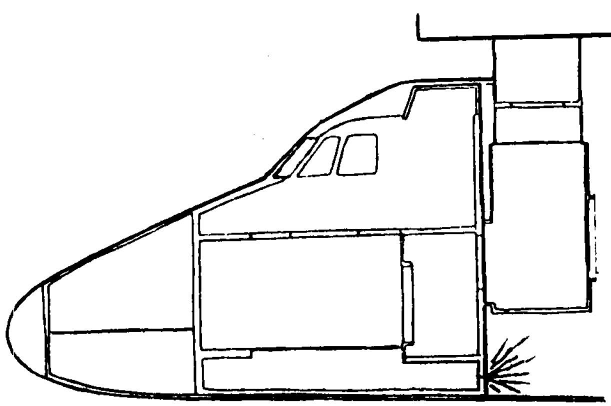


* NOT CONSIDERED VIABLE TO EGRESS DIRECTLY TO CABIN BECAUSE OF CONTAMINATION POTENTIAL

** NOT CONSIDERED VIABLE TO DEPRESS/REPRESS AIRLOCK WHILE OCCUPIED

Rev.

ACCIDENTAL DECOMPRESSION



LOCATIONS

- ORBITER CABIN
- ATTACHED MODULE

CAUSES

- SEAL FAILURE
- IMPACT DAMAGE
- VALVE FAILURE
- STRUCTURAL FAILURE

AIRCRAFT DECOMPRESSION EXPERIENCE

TYPE	TOTAL DECOMPRESSIONS	DECOMPRESSION RATE PER 100,000 HRS ABOVE 50,000 FT
B-57F	15	35
F-101	29	0
F-102	28	0
F-104	8	0
F-106	9	-
U-2	311	1300
X-1	1	-

X-15 EXPERIENCE

199 FLIGHTS

24 ACCIDENTAL DECOMPRESSIONS

TYPICAL CAUSES:

- WINDOW SEAL FAILURE
- CABIN PRESSURE REGULATOR
- "O" RING AROUND CANOPY SEAL REGULATOR
- CANOPY SEAL FAILURE TO INFLATE

ORBITER DECOMPRESSION CREDIBILITY

TYPE	PROBABILITY	EFFECTIVE HOLE DIAMETER
COLLISION WITH ORBITING DEBRIS[1]	0.01/10 yrs.	0 - 10" (disaster)
SEAL FAILURE	VIABLE	0 - 4"
VENT VALVE FAILURE	VIABLE	0 - 1/2"
METEOROID	0.001/10 yrs.	0 - 2" (> 1 gm is disaster)
DEPLOYMENT/DOCKING ACCIDENT	VIABLE	0 - 1/2"
EXPLOSION DAMAGE	UNLIKELY	-
STRUCTURAL FLAW	UNLIKELY	0 - 1/4" (> 1/4" is disaster)

NOTES:

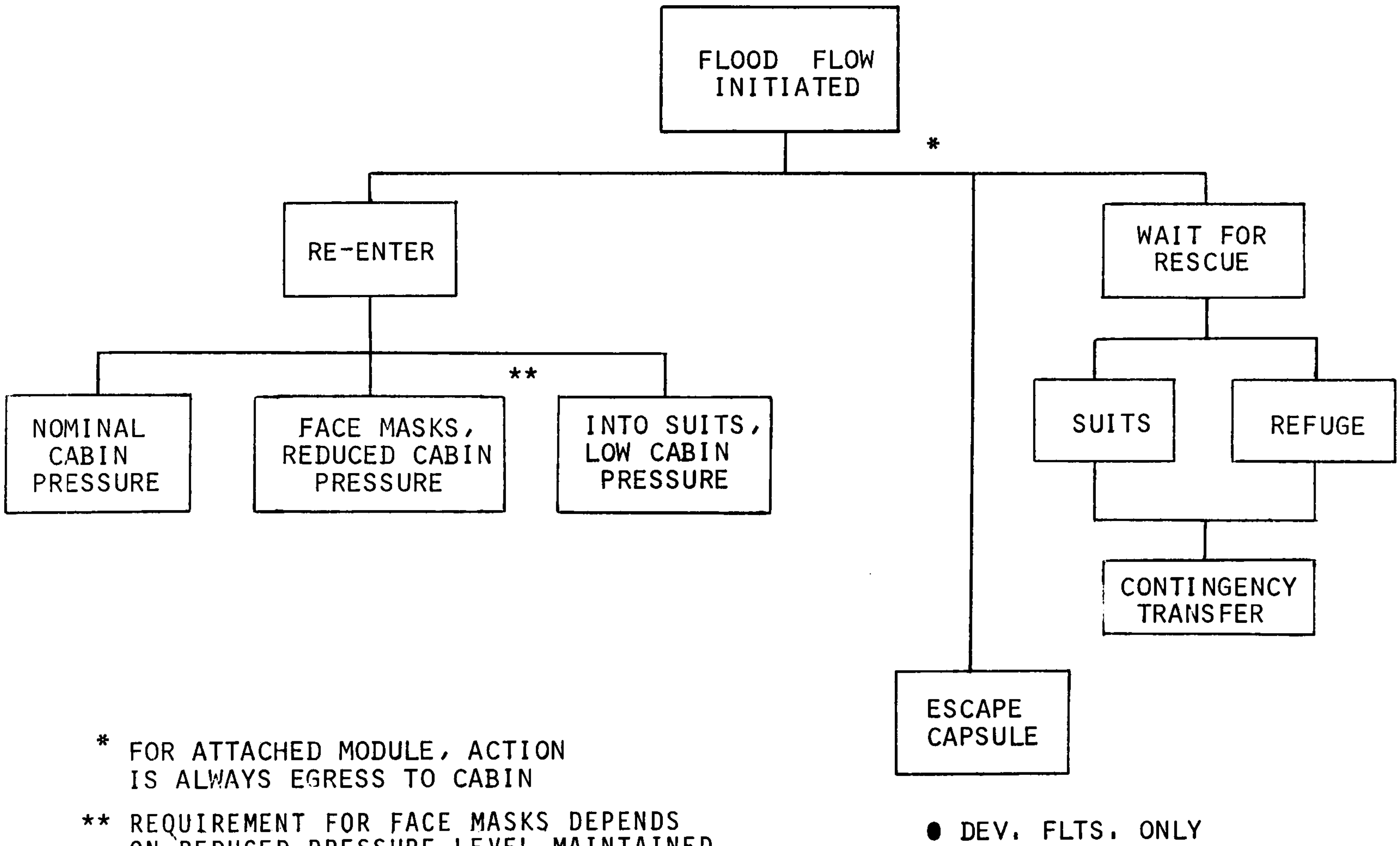
1. Based on US tracking of only 2000 objects, assumes equal number untracked
2. Sources: NR current and Modular Space Station studies; NASA-JSC studies

Rev.

ASSESSMENT OF DECOMPRESSIONS

- DECOMPRESSIONS ASSOCIATED WITH VEHICLE FAILURES ARE LIKELY TO BE LESS THAN 1/2" EFFECTIVE DIAMETER (REDUNDANT SEALS PRECLUDE PROBABILITY OF LARGE LEAK)
- DEBRIS COLLISION PROBABILITY CAN BE GREATLY REDUCED BY INCREASED TRACKING - ESPECIALLY LARGE OBJECTS
- ANY IMPACT CAUSING PENETRATION WILL LIKELY DAMAGE TPS SUCH THAT CANNOT RE-ENTER (DEBRIS, METEOROID, DEPLOYMENT/DOCKING)
- CERTAIN HAZARDOUS SITUATIONS CAN BE ANTICIPATED (DEPLOYMENT/DOCKING)
- ABOVE CONSIDERATIONS DIVIDE PROTECTION REQUIREMENTS:
  - CAPABILITY TO RE-ENTER NEEDED WITH HOLES LESS THAN 1/2" DIA
  - REPAIR OR RESCUE/ESCAPE CAPABILITY NEEDED FOR CASE OF IMPACT DAMAGE
  - PROTECTIVE MEASURES DURING KNOWN HAZARDS

VIABLE DEPRESSURIZATION OPTIONS

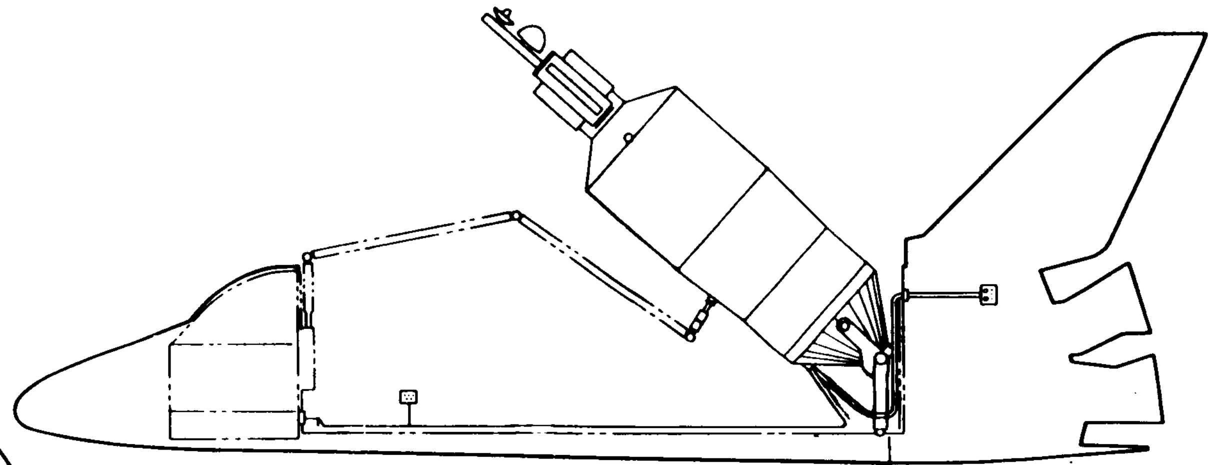


* FOR ATTACHED MODULE, ACTION IS ALWAYS EGRESS TO CABIN

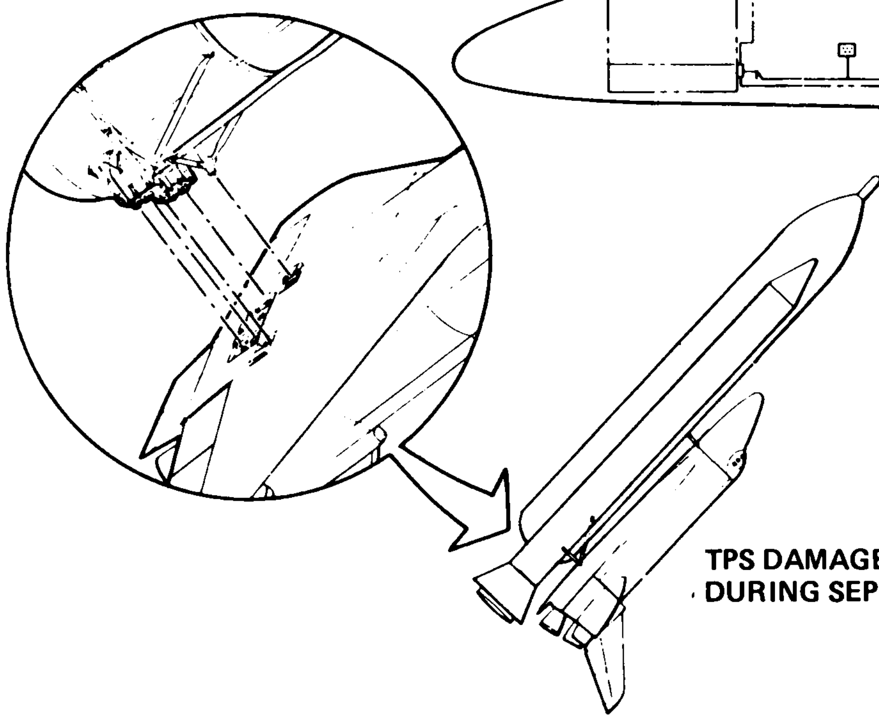
** REQUIREMENT FOR FACE MASKS DEPENDS ON REDUCED PRESSURE LEVEL MAINTAINED

Rev.

INABILITY TO RE-ENTER



CARGO BAY DAMAGE
DURING PAYLOAD HANDLING



TPS DAMAGE
DURING SEPARATION

CAUSES

- EXTERIOR DAMAGE
- FAILURE TO RETRACT
- UNSAFE PAYLOAD

INABILITY TO RE-ENTER CREDIBILITY

CAUSE	INCIDENT	PROBABILITY
EXTERNAL DAMAGE	SEPARATION ACCIDENT (100%)*	UNKNOWN
	DOCKING ACCIDENT (35%)	UNLIKELY
	CARGO MANIPULATION ACCIDENT (78%)	VIABLE
	ORBITING DEBRIS (100%)	0.01/10 yrs.
	METEOROIDS (100%)	0.001/10 yrs.
	BOOSTER ROCKET IMPINGEMENT (100%)	UNLIKELY
FAILURE TO RETRACT	DEPLOYED PAYLOAD (78%)	VIABLE
	MANIPULATOR ARMS (78%)	UNLIKELY
	CARGO BAY DOORS (100%)	UNLIKELY
UNSAFE PAYLOAD	CARGO SHIFT (33%)	VIABLE
	SECONDARY DAMAGE FROM EXPLOSION IN CARGO BAY (48%)	VIABLE

* ESTIMATED PERCENT OF APPLICABLE FLIGHTS, BASED ON OCT. 1972 NASA-JSC TRAFFIC MODEL

Rey.

UPPER STAGE EXPLOSIVES

	TUG	AGENA	CENTAUR	TRANSTAGE	BURNER II
PRESSURIZED CONTAINERS & MUTUALLY REACTIVE:					
NITROGEN TETROXIDE				X	
AEROZENE -50				X	
HYDROGEN PEROXIDE			X		X
LIQUID OXYGEN	X		X		
LIQUID HYDROGEN	X		X		
UNSYMMETRICAL DIMETHYL HYDRAZINE		X			
INHIBITED RED FUMING NITRIC ACID		X			
PRESSURIZED CONTAINERS:					
HELIUM	X	X	X	X	
NITROGEN		X		X	X
MONOPROPELLANTS:					
AEROZENE-50				X	
HYDROGEN PEROXIDE			X		X
SOLID PROPELLANT		X			X
UNSYMMETRICAL DYMETHYL HYDRAZINE		X			
EXPLOSIVE CHARGES:					
HELIUM VALVES.		X		X	
SOLID PROPELLANT IGNITERS					X
TURBINE START SOLID PROPELLANT CHARGES.		X			
EXPLOSIVE BOLTS-PAYLOAD SEPARATION	X	X	X	X	X
LINEAR SHAPED CHARGE-PANEL SEPARATION		X	X		
DESTRUCT SHAPED CHARGES	X	X	X	X	X

- BASED ON "SAFETY IN EARTH ORBIT", NR SD72-SA-0094-2, JULY 12, 1972
- 48% OF FLIGHTS INVOLVE UPPER STAGES, BASED ON OCT. 1972 NASA-JSC TRAFFIC MODEL

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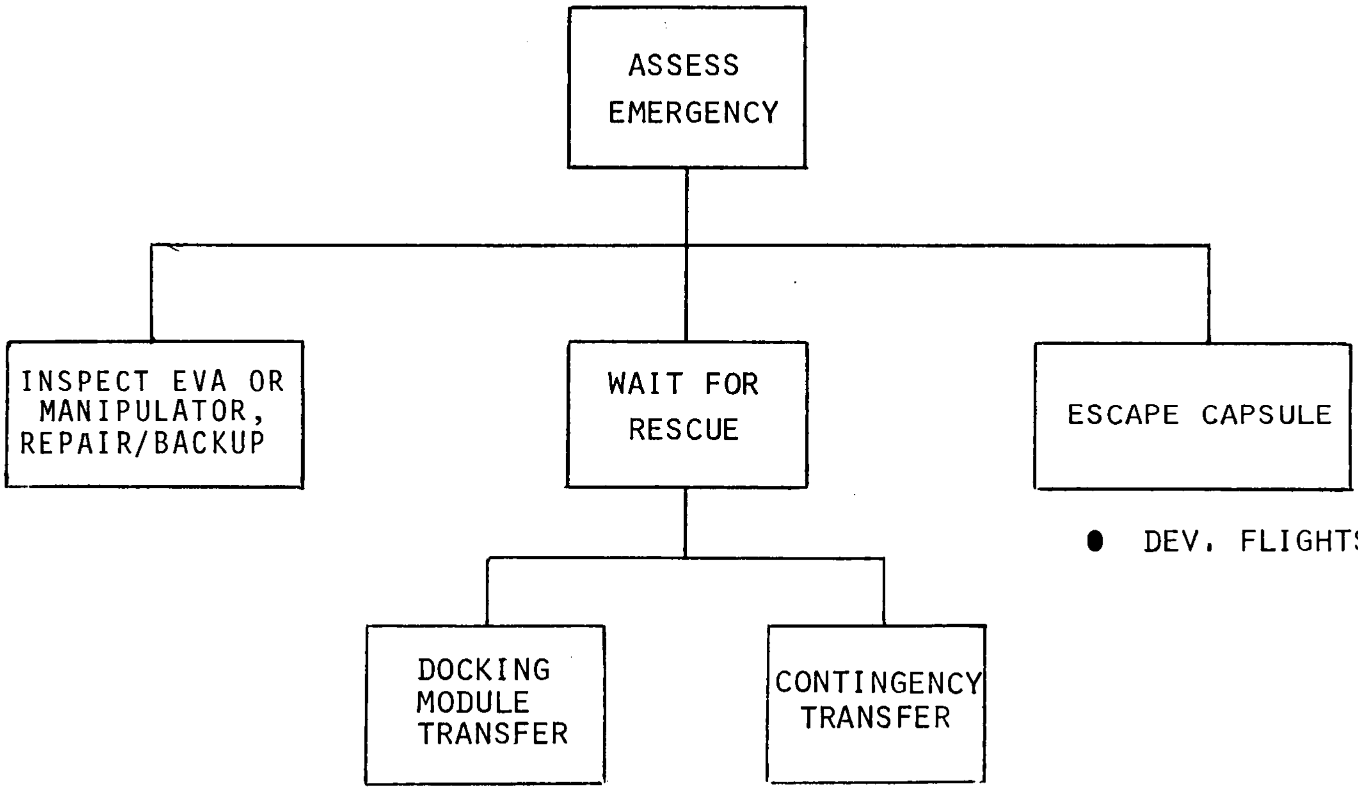
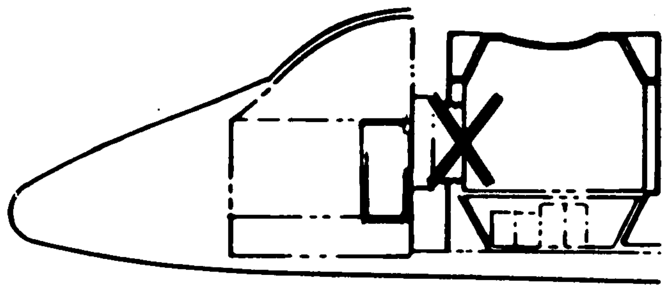
INABILITY TO RE-ENTER OPTIONS



- DEV. FLIGHTS ONLY

Rev.

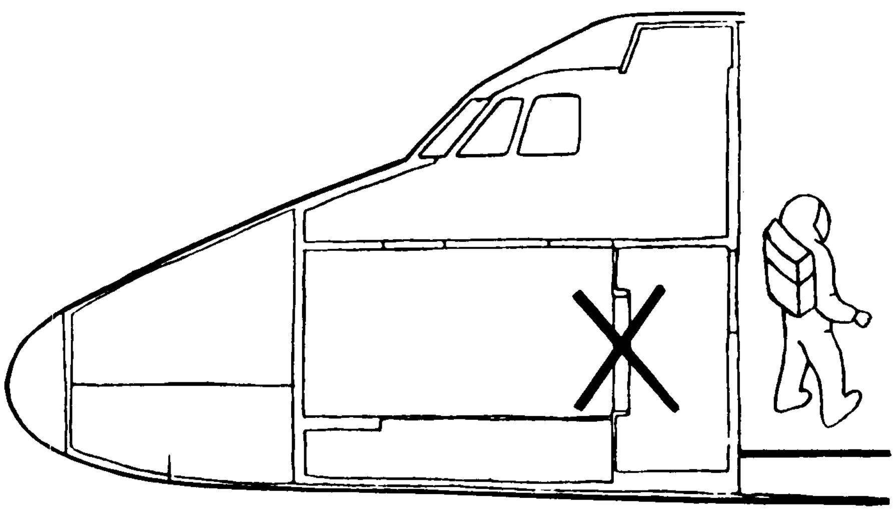
STRANDED CREWMAN



BLOCKED RETURN FROM SORTIE MODULE

LOCATIONS

- SORTIE MODULE
- DOCKING MODULE
- DOCKED FREE-FLYER
- AIRLOCK
- EVA

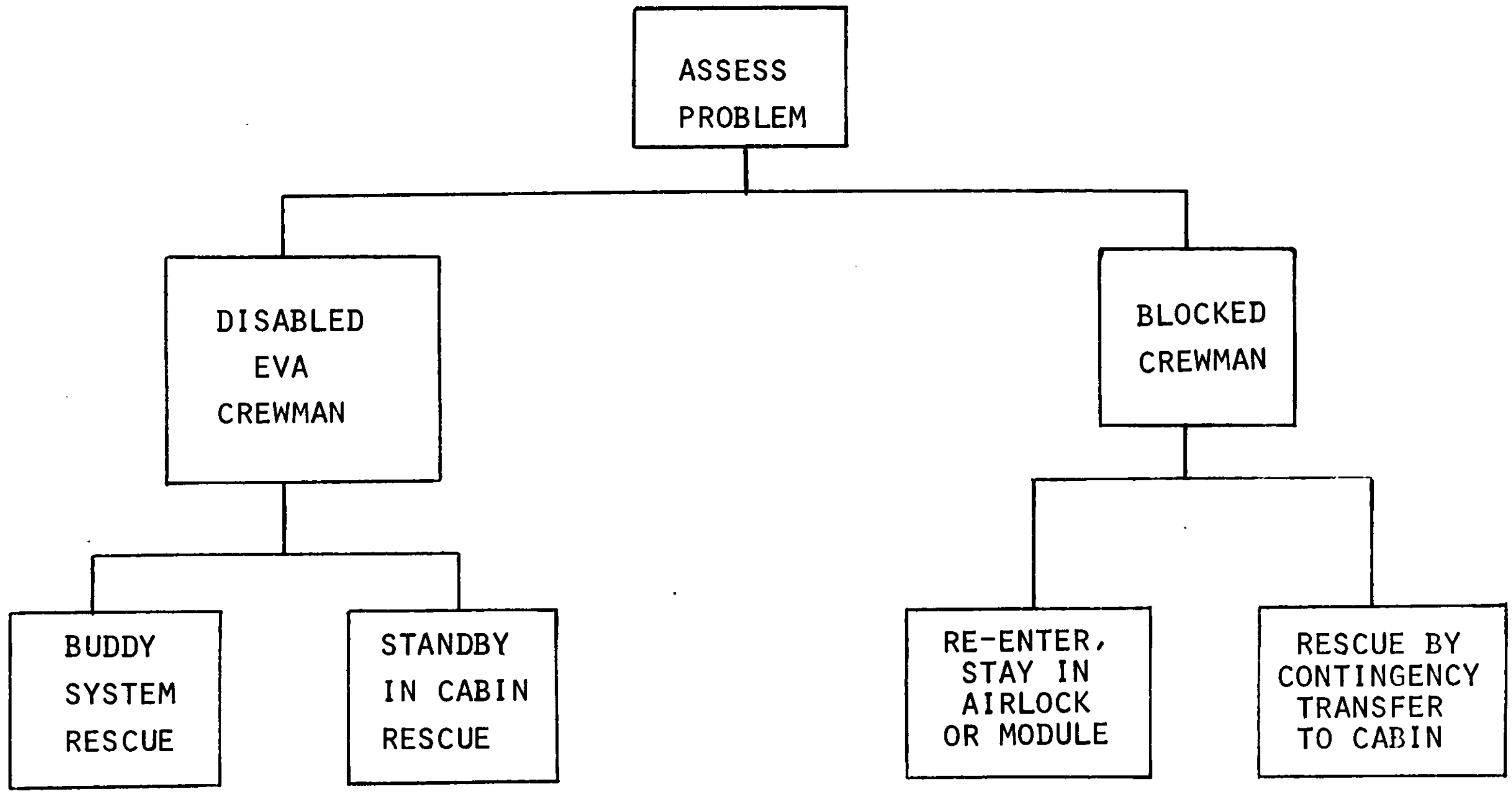


BLOCKED EVA RETURN

CAUSES

- HATCH FAILURE
- AIRLOCK SYSTEM FAILURE
- DISABLED CREWMAN
- FIRE/EXPLOSION

VIABLE STRANDED CREWMAN OPTIONS



REV.

SUMMARY OF OPTIONS

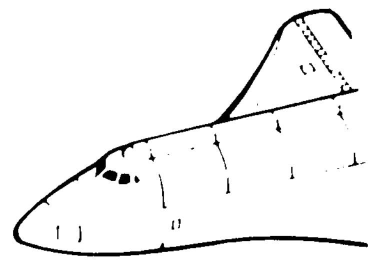
EMERGENCY	FUNCTIONAL OPTIONS	IMPLEMENTATION OPTIONS: FACE MASKS	PURGE	ECS SCRUB	DEPRESS/REPRESS	REFUGE	PURGE AIRLOCK	SUITS	EGRESS TO CABIN	MAINTAIN NOMINAL CABIN PRESSURE	MAINTAIN REDUCED CABIN PRESSURE	LOW CABIN PRESSURE	EVA	ON-ORBIT RESCUE	CONT'G, X-FER TO RESCUE VEHICLE	ESCAPE CAPSULE (DEV. FLTS. ONLY)	CONT'G, X-FER TO CABIN	BUDDY SYSTEM	STANDBY IN CABIN	REENTER IN AIRLOCK OR MODULE
CONTAMINATED ATMOSPHERE	DECONTAMINATE (CABIN OR MODULE)	✓	✓																	
		✓		✓																
		✓			✓			✓												
		✓				✓	✓													
	ABORT MISSION (CABIN)	✓																		
	ABORT MODULE	✓				✓	✓		✓											
DECOMPRESSION	RE-ENTER (CABIN)									✓										
		✓									✓									
								✓				✓								
	WAIT FOR RESCUE (CABIN)	✓						✓						✓	✓					
						✓		✓						✓	✓					
	ESCAPE (CABIN)															✓				
	ABORT MODULE								✓											
INABILITY TO RE-ENTER	REPAIR/CORRECT							✓					✓							
	WAIT FOR RESCUE													✓						
								✓						✓	✓					
	ESCAPE															✓				
STRANDED CREWMAN	RESCUE DISABLED EVA CREWMAN							✓					✓					✓		
								✓					✓						✓	
	RESCUE BLOCKED CREWMAN							✓									✓			
	RE-ENTER (BLOCKED CREWMAN)																			✓

Rev.

IMPACTS

- FLOOD FLOW
- DEPRESS/REPRESS
- AIRLOCK AS REFUGE
- SUITS
- CONTINGENCY TRANSFER
- DEVELOPMENT FLIGHTS

FLOOD FLOW CONSIDERATIONS



POTENTIAL USES

- MAINTAIN CABIN PRESSURE
  - FOR RE-ENTRY
  - UNTIL DON SUITS
  - UNTIL REACH AIRLOCK REFUGE
- HOLD ATTACHED MODULE PRESSURE UNTIL REACH AIRLOCK OR CABIN
- CABIN CONTAMINATION PURGE
- AIRLOCK CONTAMINATION PURGE
- ATTACHED MODULE PURGE
- AIRLOCK CONTINGENCY REPRESS

CABIN PRESSURE MAINTENANCE OPTIONS

MAINTAIN NEAR-NOMINAL CABIN PRESSURE

- CURRENTLY 14.7 PSIA, 10 PSIA ALTERNATE UNDER EVALUATION
- SIMPLEST SYSTEM

MAINTAIN REDUCED CABIN PRESSURE (INITIAL 14.7 $\pm$ .2)

- INCREASED DURATION
- STRUCTURAL/VENT IMPACTS
- 10 PSIA : MINIMUM TEMPORARY WITHOUT OXYGEN MASKS*
  (USAF EMERGENCY ALVEOLAR ppO_2 = 50 mm Hg, IMPAIRED PERFORMANCE)
- 8 PSIA : MINIMUM WITHOUT DECOMPRESSION SICKNESS OR MAJOR AVIONICS IMPACTS, OXYGEN MASKS REQUIRED*

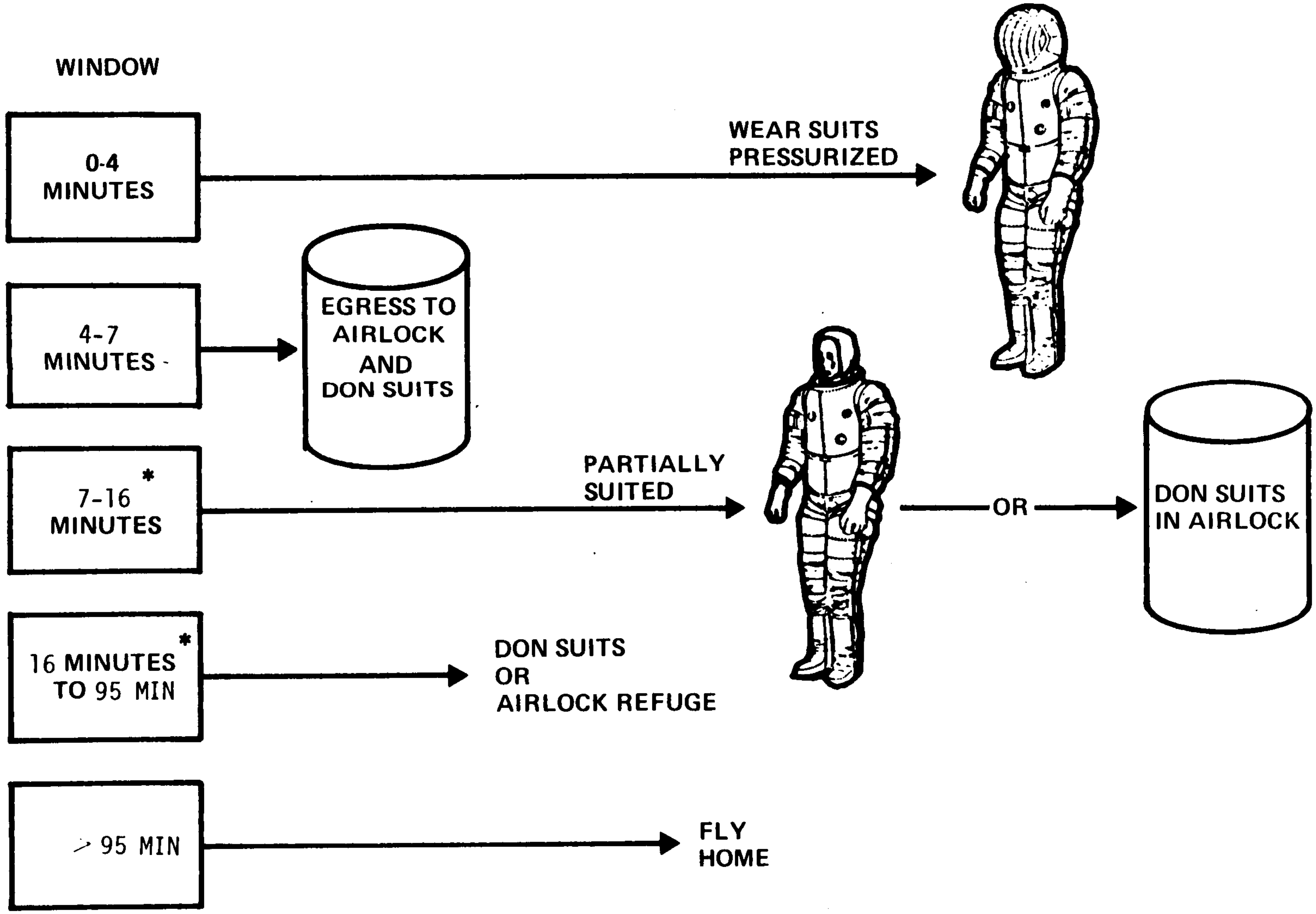
MAINTAIN LOW CABIN PRESSURE

- FURTHER INCREASED DURATION
- STRUCTURAL/VENT IMPACTS
- ADDITIONAL AVIONICS COOLING REQUIRED (SIGNIFICANT IMPACT)
- APPROX. 2 PSIA : AVIONICS MINIMUM PRESSURE CAPABILITY
- PRESSURE SUITS REQUIRED

* FOR WORST CASE OXYGEN TRANSIENT CONCENTRATION GRADIENTS

REV.

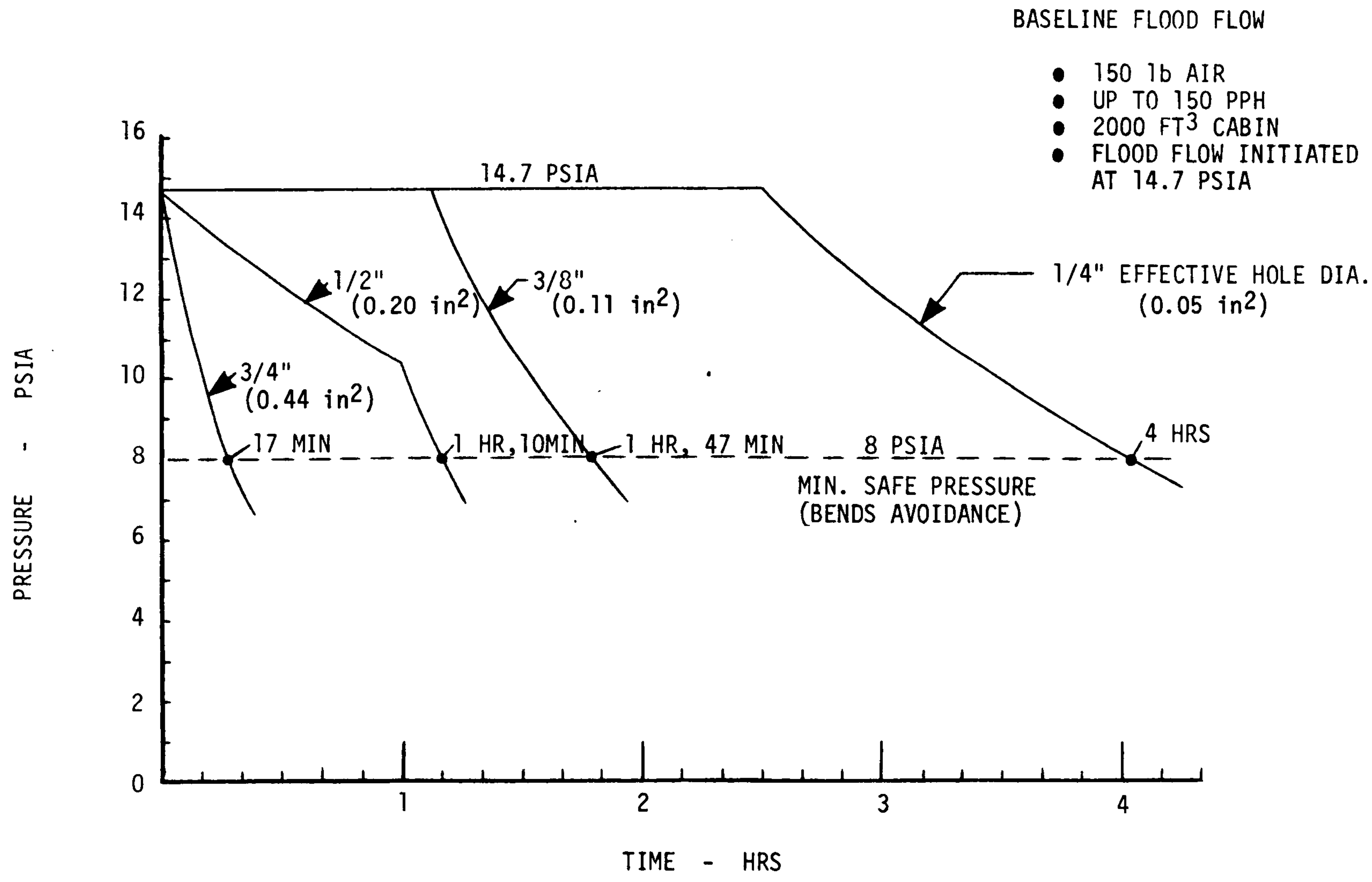
DECOMPRESSION RATE CONSIDERATIONS



*16 MINUTES FOR SHORT DURATION SUIT CONFIGURATION, 20 MINUTES FOR LONG DURATION CONFIGURATION

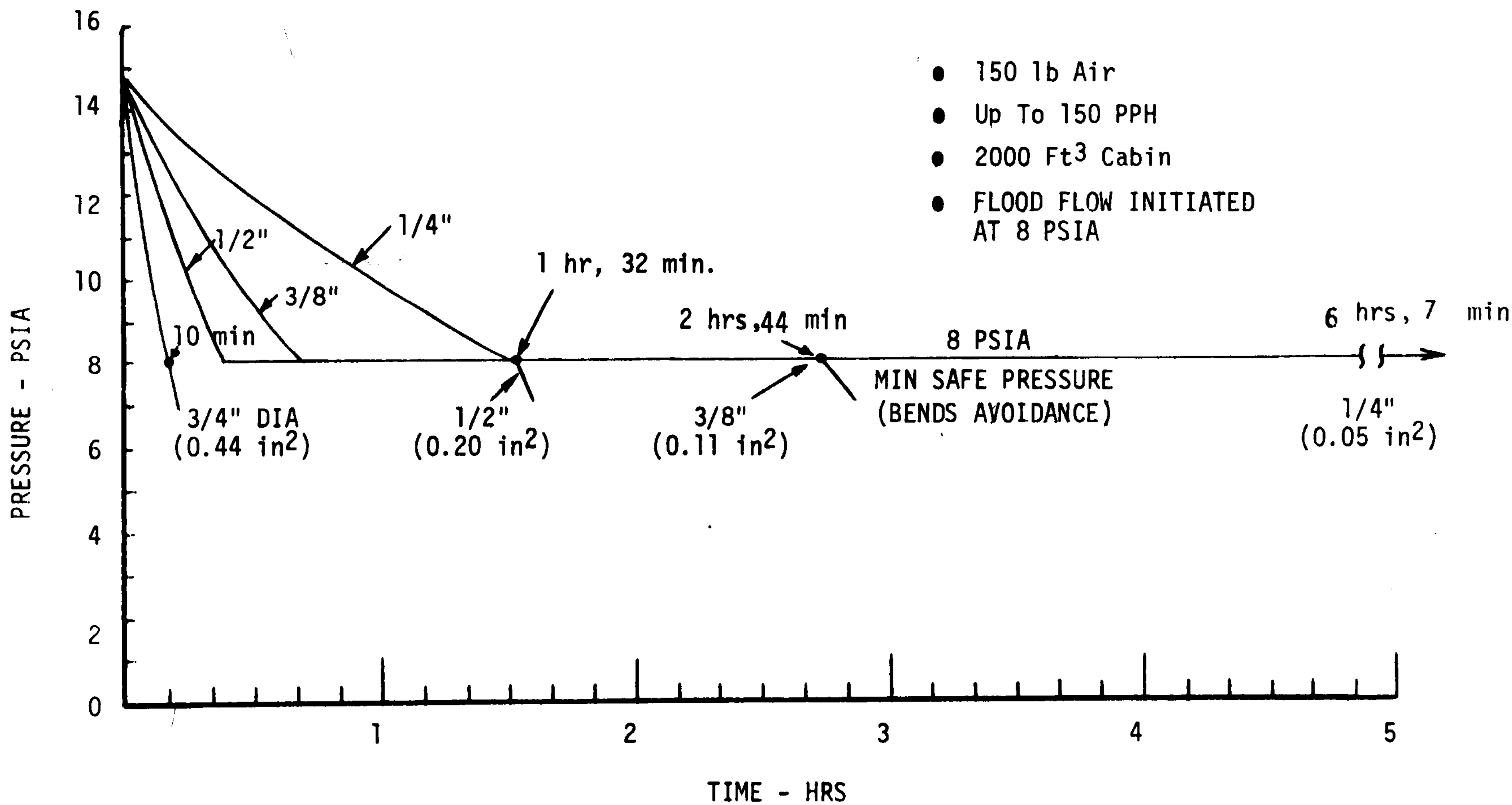
Rev.

CABIN DEPRESSURIZATION RATE



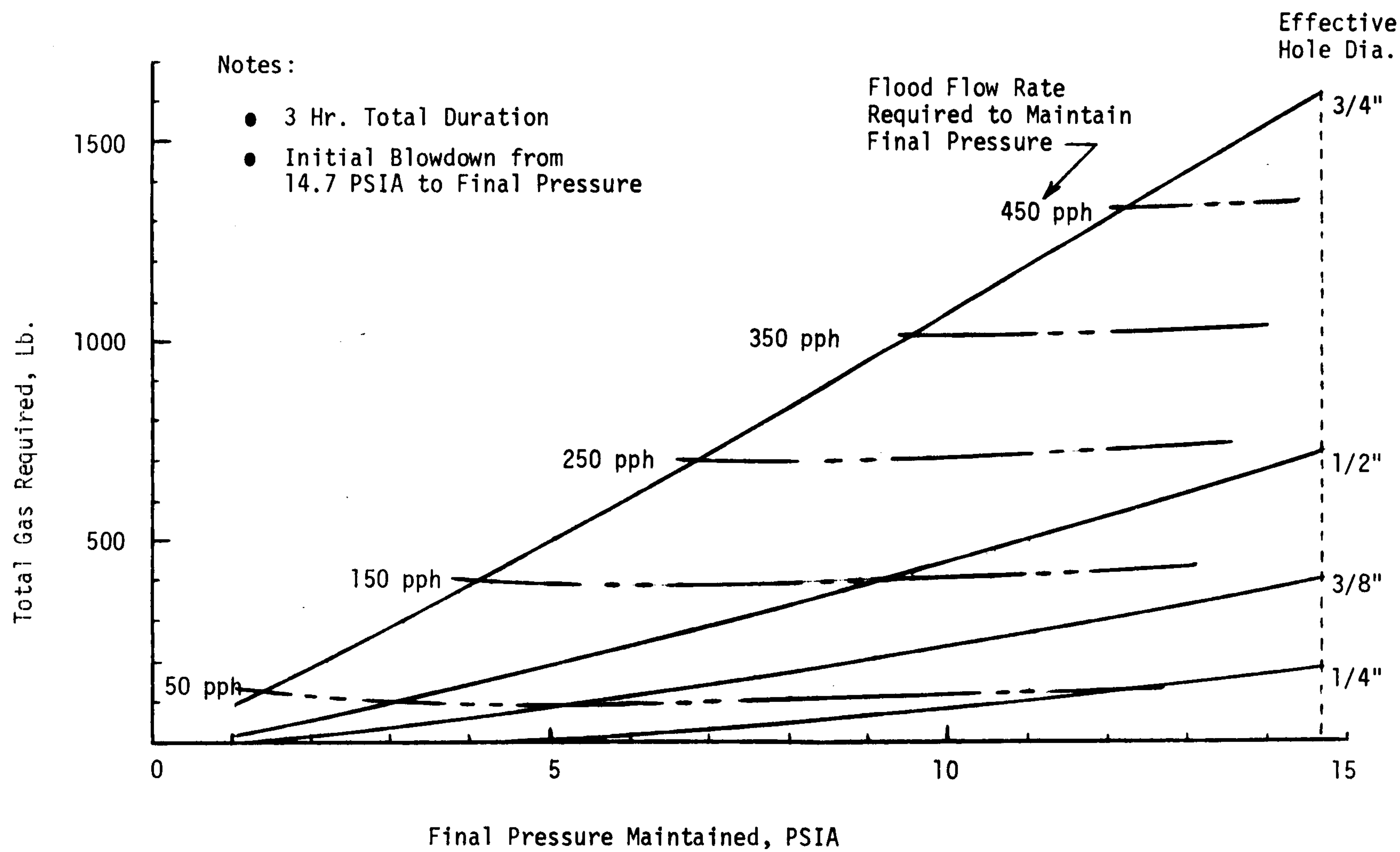
Rev.

DEPRESSURIZATION RATE AT 8 PSIA HOLD



Rev.

FLOOD FLOW GAS REQUIREMENTS



FLOOD FLOW GAS REQUIREMENTS SUMMARY

EFFECTIVE HOLE DIA. (INCH)	FLOOD FLOW RATE (PPH) FOR PRESSURE MAINTAINED (PSIA)				TOTAL GAS (LB) FOR PRESSURE MAINTAINED (PSIA)			
	2	8	10	14.7	2	8	10	14.7
1/4	8	33	40	60	0	49	80	180
3/8	19	74	92	135	15	171	236	405
1/2	34	132	164	240	58	345	454	720
3/4	74	295	367	540	180	836	1064	1620

NOTES:

1. 3 HR TOTAL DURATION, 165 MIN QUICK RETURN + 15 MIN CONTINGENCY
2. INITIAL BLOWDOWN FROM 14.7 TO MAINTAINED PRESSURE; HELD THERE UNTIL END OF 3 HRS

Rev.

EVALUATION OF CABIN PRESSURE LEVELS MAINTAINED

	FINAL CABIN PRESSURE, PSIA		
	14.7	10	8
3 Hour Return - Max. Hole Dia (1)	7/32"	5/16"	3/8"
95 Min. Return - Max. Hole Dia (1)	9/32"	7/16"	1/2"
1/2" Dia. Hole Gas Reqt's. (1) - 95 Min. Return	240 pph, 380 lb (2)	165 pph, 220 lb (2)	132 pph, 155 lb
Emergency Gas Utilization	Depletes N_2 at 60% O_2 Depletion, Continues Makeup with O_2	Depletes N_2 & O_2 At Same Time	Depletes O_2 at 70% (3) N_2 Depletion, Then Baseline Shuts Off N_2
Alveolar Oxygen: (4) Nominal Range	105 100 - 110 mm Hg	101 47 - 106 mm Hg	98 26 - 102 mm Hg
Oxygen Masks (4)	Not Required	Marginal	Required
Flammability	22 - 24% O_2; 100% after N_2 Depletion	32 - 36% O_2	39 - 44% O_2 Until O_2 Depletion
Structural/Relief Valve Modifications	None	Required	Required

NOTES:

(1) Calculated for blowdown from 14.7 to final pressure prior to initiation of flood flow-does not consider unequal N_2/O_2 depletion.

(2) Extra tankage and increased flow capacity required

(3) Regulator change required to avoid N_2 regulator lock-out when O_2 is depleted

(4) 90 mm Hg is min. alveolar O_2 for unimpaired performance; 50 mm Hg is USAF emerg. level and gives performance impairment. Alveolar range is due to potential concentration gradient and control tolerance bands

(5) Evaluation is for baseline system, assuming only those changes required to operate at given pressure levels

Rev.

FLOOD FLOW PRESSURE MAINTENANCE SUMMARY

- 14.7 PSIA PRESSURE MAINTENANCE
  - Baseline orbiter not safe for re-entry (95 min.) with effective hole diameter larger than about 1/4"
  - Excessive makeup gas system mods. to hold 1/2 inch hole for 95 min. (230 lb. extra gas; 60% increased flowrate; tankage ratio mods. to deplete O_2/N_2 at same time)
- 10 PSIA PRESSURE MAINTENANCE
  - Modest makeup gas system mods. to hold 1/2" hole for 95 min. (70 lb. extra gas; 10% increased flowrate; regulator change)
  - Safe without oxygen masks, including transient concentration gradients
  - Increases fire hazard a modest amount (10-12% greater oxygen concentration than 14.7 psia baseline)
  - Minimal structural/vent/avionics impacts (undefined)
- 8 PSIA PRESSURE MAINTENANCE
  - Minimal makeup gas system mods. to hold 1/2" hole for 95 min. (no extra gas or flowrate; tankage ratio mods. to deplete O_2/N_2 at same time; regulator change)
  - Oxygen masks required because of potential transient concentration gradients
  - Increases fire hazard somewhat more (17-20% greater oxygen concentration than 14.7 psia baseline)
  - Minimal structural/vent/avionics impacts (undefined)
- 2 PSIA PRESSURE MAINTENANCE
  - Least makeup gas system mods. to hold 1/2" hole for 95 min. (regulator change only)
  - Requires pressure suits with oxygen mask use during donning
  - 100% cabin oxygen concentration at 2 psia (baseline makeup system)
  - Excessive structural/vent/avionics impacts (undefined)

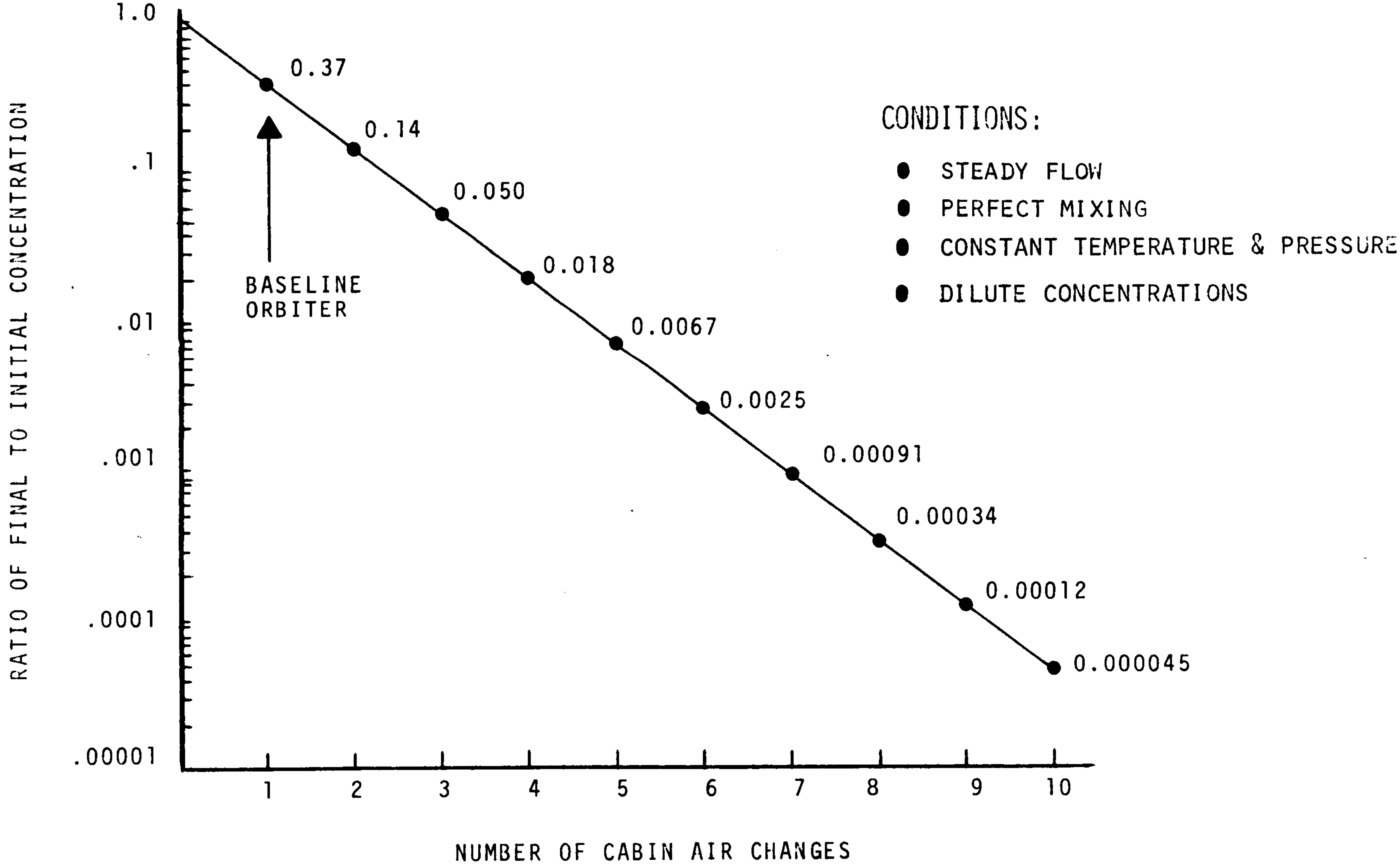
Rev.

FLOOD FLOW CONCLUSIONS - MAINTENANCE OF PRESSURE

- FOR HOLES UP TO 1/2" EFFECTIVE DIA., 8-10 PSIA PRESSURE MAINTENANCE FOR 95 MIN. RETURN IS PRACTICAL, DOES NOT INVOLVE EXCESSIVE PENALTIES, AND PERMITS SHIRTSLEEVE RE-ENTRY. FURTHER STUDY REQUIRED TO SELECT 8 OR 10.
- FOR HOLES LARGER THAN 1/2" EFFECTIVE DIA., MAINTENANCE OF PRESSURE ABOVE 8 PSIA FOR 95 MIN. RETURN IS NOT PRACTICAL, AND PRESSURE SUIT OPERATION IS REQUIRED.
- GAS REQUIREMENTS FOR 3 HR. SHIRTSLEEVE RETURN ARE IMPRACTICAL FOR HOLE SIZES OF 1/2" EFFECTIVE DIA. (345 LB @ 8 PSIA, 454 LB @ 10 PSIA)
- FOR HOLES UP TO ABOUT 3/4" EFFECTIVE DIA., THE BASELINE FLOOD FLOW CAPABILITY OF 150 pph HOLDS PRESSURE ABOVE 8 PSIA LONG ENOUGH TO DON PRESSURE SUITS. FLOW MUST BE INITIATED AT NEAR 14.7 PSIA AND OXYGEN MASK MAY BE REQUIRED. SUBSEQUENT REDUCED PRESSURE RE-ENTRY (2 PSIA OR LESS), ON-ORBIT RESCUE, OR USE OF ESCAPE MODULE IS REQUIRED.
- FOR HOLES GREATER THAN 3/4" EFFECTIVE DIA., CONSTANT WEAR SUITS ARE ONLY SAFE ALTERNATIVE. SUBSEQUENT DEPRESSURIZED RE-ENTRY, ON-ORBIT RESCUE, OR USE OF ESCAPE MODULE IS REQUIRED.

Rev.

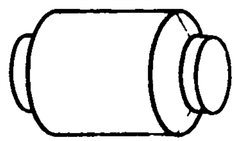
CONTAMINATION PURGING EFFECTIVENESS



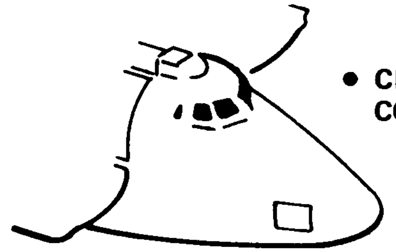
FLOOD FLOW CONCLUSIONS - PURGE CONTAMINATION

- BASELINE ORBITER PURGE QUANTITY INSUFFICIENT TO CLEAR CABIN (63% REDUCTION; MUST INCREASE TO 700 LB GAS FOR REDUCTION TO 1% INITIAL CONCENTRATION)
- SIMILARLY IMPRACTICAL TO CLEAR SORTIE MODULE BY PURGE
- REDUCED PRESSURE PURGE IS POSSIBLE, BUT STILL CARRIES HIGH PENALTY (AT 8 PSIA LEVEL, APPROX. 350 LB PURGE GAS IS NEEDED FOR CABIN REDUCTION TO 1% INITIAL CONCENTRATION)
- BASELINE ORBITER PURGE QUANTITY SUFFICIENT TO CLEAR AIRLOCK

DEPRESS/REPRESS CONSIDERATIONS



SORTIE LAB



CABIN

PURPOSE

- CLEAR CONTAMINATED CABIN IF CANNOT RE-ENTER WITHIN SHORT DURATION
- CLEAR CONTAMINATED ATTACHED MODULE

IMPACTS

- TEMPORARY OPERATION DEPRESSURIZED
- ADD VALVING TO DUMP PRESSURES; *COULD DUMP CABIN THROUGH AIRLOCK IF WEAR SUITS (ABOUT 1 HR DUMP TIME)
- EXISTING CABIN FLOOD FLOW PROVISIONS ADEQUATE TO REPRESS IN 1 HOUR
- SUITS OR REFUGE LIFE SUPPORT REQUIRED FOR 2 HOURS

CONCLUSION

- DEPRESS/REPRESS IS PRACTICAL WAY TO CLEAR CONTAMINATION

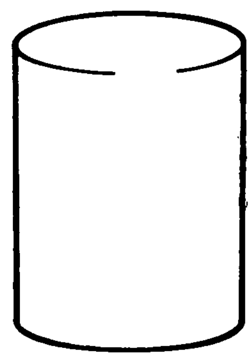
ALTERNATES

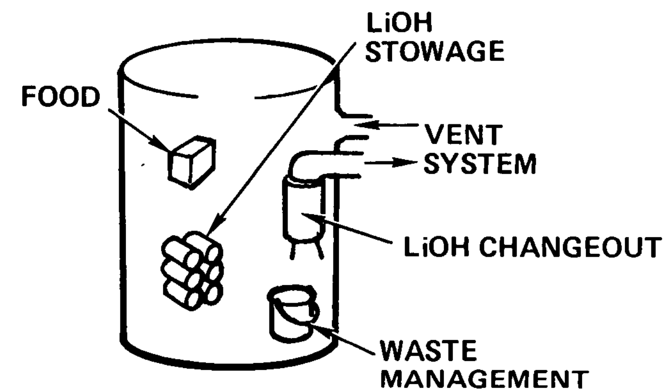
- LONG TERM FACE MASK USE (DISCOMFORT, OXYGEN TOXICITY, ADDITIONAL CONSUMABLE O_2)
- INCREASE PURGE CAPABILITY (HIGH PENALTY)
- SCRUB SMOKE WITH ECS

*OR MANUALLY OPEN RELIEF VALVE

Rev.

AIRLOCK AS REFUGE





POTENTIAL USES

- TEMPORARY FOR SUIT DONNING IN EVENT OF DECOMPRESSION - PROVIDES QUICKEST ROUTE TO SAFETY (16-20 MINUTE OCCUPANCY NEEDED FOR SUIT DONNING)
- TEMPORARY WHILE DEPRESS/REPRESS CABIN OR SORTIE LAB - MUST SIMULTANEOUSLY PURGE AIRLOCK (2 HOUR OCCUPANCY)
- TEMPORARY DURING PURGE WHILE EGRESS FROM CONTAMINATED SORTIE LAB TO CABIN (30 MINUTES TO 1 HOUR OCCUPANCY)
- LONG TERM WHILE WAIT FOR ON-ORBIT RESCUE (96 HOURS)
- TEMPORARY FOR FOOD AND WASTE MANAGEMENT DURING SUITED LONG TERM WAIT

EVALUATION OF AIRLOCK REFUGE

PHYSICAL

- LARGE ENOUGH FOR 2-MAN SUIT DONNING, 4 MEN SHIRTSLEEVES
- ENLARGE OR ADD DOCKING MODULE FOR LARGER CREW

ECS

- 144 FT^3 AIRLOCK WILL SUSTAIN 2 SHIRTSLEEVES MEN 41 MINUTES, 4 MEN 34 MINUTES - 300 BTU THERMAL STORAGE IS LIMITING
- OCCUPANCY DURING AIRLOCK PURGE WOULD REQUIRE NO ADDITIONAL ECS
- SUIT ECS LOOPS AND UMBILICALS REQUIRED IF USE FOR SUIT DONNING
- SIMPLE AIRLOCK ECS REQUIRED IF USE AS REFUGE DURING CABIN OR SORTIE LAB DEPRESS/REPRESS OR FOR TEMPORARY FOOD/WASTE MANAGEMENT
- MAJOR ECLSS MODIFICATIONS, SUITS, AND CONTINGENCY TRANSFER LSS REQUIRED FOR LONG TERM REFUGE

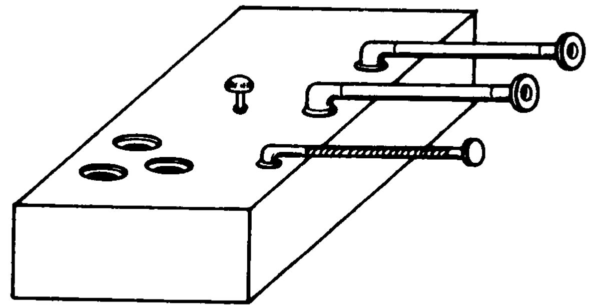
CONCLUSIONS

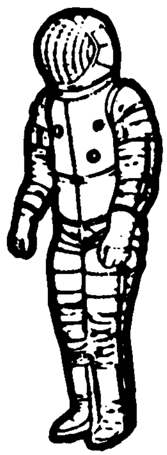
- NO IMPACT AS TEMPORARY REFUGE FOR PURGE DURING EGRESS FROM CONTAMINATED SORTIE LAB
- CONDUCT SORTIE LAB DEPRESS/REPRESS FROM CABIN
- NOT PRACTICAL AS LONG TERM REFUGE
- REMAINING USES SHOULD BE TRADED AGAINST OTHER ALTERNATIVES

IV SUITS AND CONTINGENCY LSS

POTENTIAL USES

- DEPRESSURIZED OR LOW PRESSURE OPERATIONS/REENTRY
- LONG TERM DEPRESSURIZED WAIT FOR ON-ORBIT RESCUE
- CONTINGENCY TRANSFER TO RESCUE SHUTTLE
- CONTINGENCY TRANSFER OF BLOCKED CREWMAN INTO CABIN SIDE HATCH
- CABIN DEPRESS/REPRESS TO CLEAR CONTAMINATION



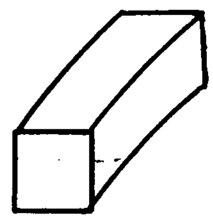


CONTINGENCY IV LSS

- INTERFACES EXISTING ORBITER ECLSS
- COMMON USE OF EXPENDABLES
- ALTERNATE CARRY-ON SYSTEM
- FEASIBILITY STUDIES COMPLETED

8 PSIA SUITS

- PROTOTYPE UNDER DEVELOPMENT
- REQUIREMENTS DETERMINED FOR MINIMUM ORBITER IMPACT



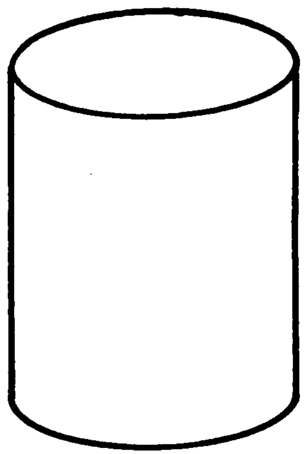
PORTABLE CONTINGENCY TRANSFER LSS

- COMMONALITY WITH EMERGENCY EVA SYSTEM FOR PLANNED ACTIVITIES

EVALUATION OF IV SUITS

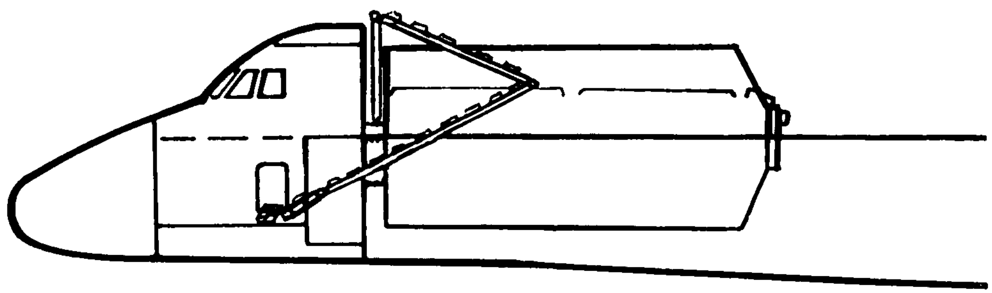
- ONLY PRACTICAL MEANS FOR SURVIVAL IN DEPRESSURIZED CABIN WHILE WAITING FOR ON-ORBIT RESCUE
- ONLY WAY TO PROTECT AGAINST LARGE LEAKS (CONSTANT WEAR)
- CAN WEAR INTERMITTENTLY TO PROTECT DURING HAZARDOUS OPERATIONS
- PERMITS RE-ENTRY AT LOW CABIN PRESSURES (AVIONICS AND OTHER ORBITER MODS. REQ'D., POTENTIAL SAVINGS ON FLOOD FLOW)
- PERMITS SUITED DEPRESS/REPRESS OF CONTAMINATED CABIN (SAVES AIRLOCK PURGE)
- PERMITS CONTINGENCY TRANSFER/RESCUE THROUGH CABIN SIDE HATCH

SPECIAL AIRLOCK CONSIDERATIONS
FOR STRANDED CREWMAN



- FOR ONE-MAN EVA, STANDBY PARTIALLY SUITED CREWMAN IS LOCATED IN CABIN
- CONTINGENCY REPRESS AIRLOCK AT 6.0 PSI/MIN USING CABIN AIR
- DESIGN RELIEF VALVE AND AIRLOCK DEPRESS SYSTEM TOGETHER.
- NO REQUIREMENT IDENTIFIED FOR 0→3.25 PSIA REPRESS IN 15 SECONDS

CONTINGENCY TRANSFER FROM SORTIE MODULE



DRIVER:
BLOCKED
IV ACCESS

MAJOR IMPACT:

- CONTINGENCY TRANSFER SUITS, LSS, THERMAL PROTECTION, AND TETHER IN SORTIE MODULE
- REMOTE SECOND HATCH ON SORTIE MODULE
- CONTINGENCY LSS IN SORTIE MODULE
- MOBILITY AIDS AND SIDE HATCH USE
- RESEAL SIDE HATCH BEFORE RE-ENTER

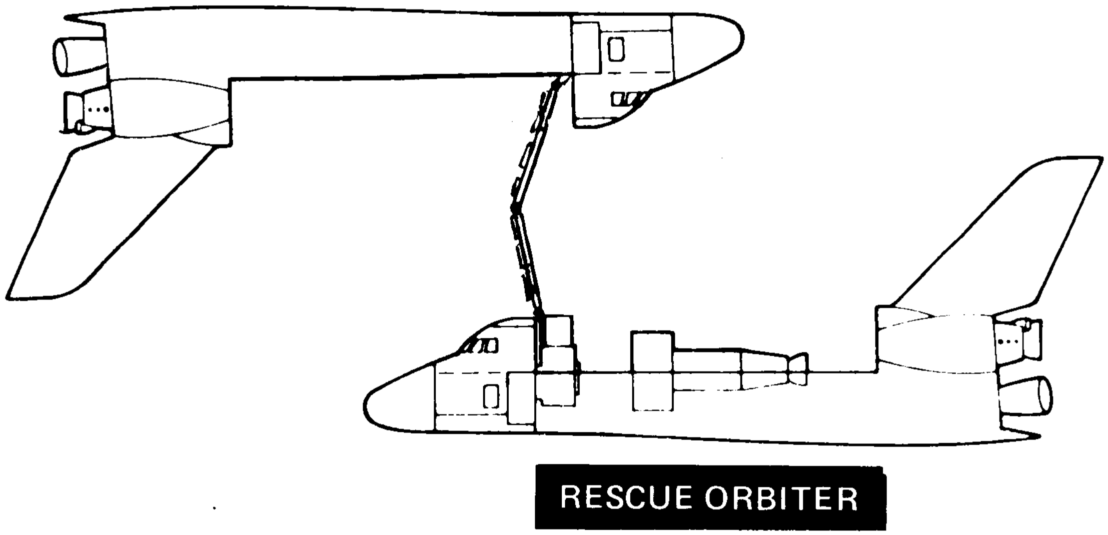
RECOMMEND:

- DESIGN TO ACCEPTABLE RISK OF NO BLOCKED ACCESS
- OPERATE SORTIE MODULE AND AIRLOCK/SORTIE MODULE HATCHES OPEN
- OPERATE CABIN/AIRLOCK HATCH CLOSED

Rev.

RESCUE ORBITER CONTINGENCY TRANSFER

DRIVER:
RESCUE ORBITER
CANNOT DOCK



REQUIREMENTS:

- MOBILITY AIDS ON RESCUE MANIPULATOR
- SUITS WITH CONTINGENCY TRANSFER LSS AND THERMAL PROTECTION
- TETHERS
- RESCUE CREWMAN

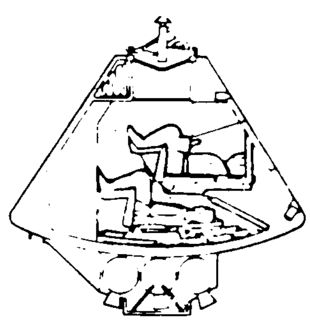
*

RESCUE ORBITER
MUST SYNCHRONIZE
WITH DISABLED
SHUTTLE DRIFT

DEVELOPMENT FLIGHTS

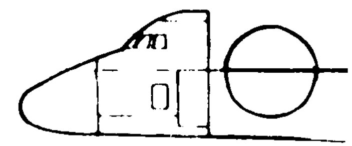
CONSIDERATIONS:
- NO RESCUE SHUTTLE
- HIGHER RISKS
- EXCESS PAYLOAD CAPACITY
- SHORT DEVELOPMENT PHASE

APOLLO COMMAND MODULE

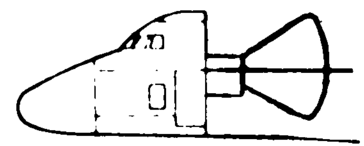


OPTIONS:

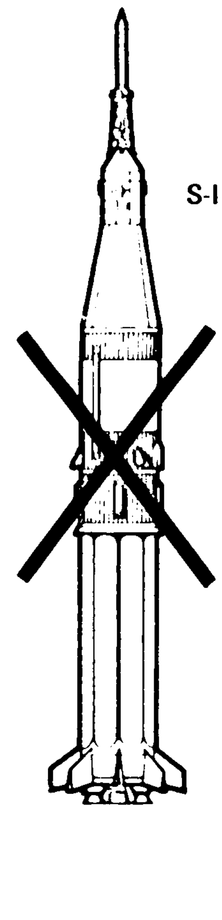
- ADDITIONAL PURGE OXYGEN/NITROGEN



- ESCAPE CAPSULE



- GROUND BASED RESCUE
- ~~TAKE THE RISK~~



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CONCLUSIONS AND RECOMMENDATIONS

- ADDITIONAL STUDY ON CREDIBILITY OF HAZARDS IS NEEDED
- IMPLEMENT A TRACKING/COLLISION AVOIDANCE SYSTEM FOR ORBITING DEBRIS
- ACCIDENTAL DECOMPRESSION IS MOST LIKELY AT EFFECTIVE HOLE DIAMETERS OF 1/2" OR LESS, AND THE CAPABILITY FOR SHIRTSLEEVE RE-ENTRY SHOULD BE PROVIDED. A REDUCED PRESSURE CABIN IN THE 8-10 PSIA RANGE IS RECOMMENDED FOR SHIRTSLEEVE RE-ENTRY.
- ACCIDENTAL DECOMPRESSION IS LESS LIKELY BUT VIABLE FOR LARGER HOLES. PRESSURE SUITS SHOULD BE WORN DURING KNOWN HAZARDOUS OPERATIONS. FLOOD FLOW SUITABLE TO MAINTAIN CABIN PRESSURE DURING SUIT DONNING SHOULD BE PROVIDED TO PROTECT AGAINST HAZARDS WHICH CANNOT BE ANTICIPATED. FURTHER STUDY IS REQUIRED TO DETERMINE THE EFFECTIVE HOLE SIZE DESIGN VALUE.
- ACCIDENTAL DECOMPRESSION COMBINED WITH INABILITY TO RE-ENTER IS VIABLE, AND THE CAPABILITY FOR ON-ORBIT RESCUE OR ESCAPE SHOULD BE PROVIDED. PRESSURE SUITS PLUS RESCUE IS RECOMMENDED FOR OPERATIONAL FLIGHTS.
- DEVELOPMENT FLIGHTS REQUIRE SPECIAL PROVISIONS FOR SAFETY
- FURTHER DEFINITION OF AVIONICS CAPABILITIES AND IMPACTS TO PERFORM MINIMUM FUNCTIONS FOR REDUCED CABIN PRESSURE RE-ENTRY AND ON-ORBIT STABILIZATION IS NEEDED
- EVALUATE DOCKING MODULE FOR USE AS CARRY-UP RESCUE DEVICE
- INVESTIGATE CABIN SMOKE CONTAMINATION POTENTIAL AND EFFECTS ON VISIBILITY. EVALUATE ECS CAPABILITY/IMPACT FOR SMOKE SCRUBBING.
- NO REQUIREMENT IDENTIFIED FOR SUITS IN SORTIE MODULE
- NO REQUIREMENT IDENTIFIED FOR 15 SEC. EMERGENCY AIRLOCK REPRESS TO 3.25 PSIA
- PURSUE THE STUDY OF THE PRELIMINARY EMERGENCY SYSTEM, DEFINED ON THE FOLLOWING PAGES, AND ITS DERIVATIVES

REV.

PRELIMINARY EMERGENCY SYSTEM

ACCIDENTAL DECOMPRESSION

1. PROVIDE FLOOD FLOW CAPABILITY FOR SHIRTSLEEVE 95 MINUTE RETURN FOR EFFECTIVE HOLE DIAMETERS UP TO 1/2 INCH:
   - COVERS LARGE NUMBER OF CASES, INCLUDING MOST VEHICLE FAILURES
   - MAINTAIN REDUCED CABIN PRESSURE OF 8-10 PSIA, USE OXYGEN MASKS BELOW 10 PSIA
   - 95 MINUTE PANIC MODE RETURN IS PROVIDED BY:
     - BASELINE EMERGENCY GAS (INCL. CRYO. O_2) FOR 8 PSIA CABIN
     - BASELINE + 70 LB GAS FOR 10 PSIA CABIN
   - MODIFY VEHICLE FOR 8-10 PSIA CABIN RE-ENTRY
2. PROVIDE SUITS AND LSS IN CABIN FOR PROTECTION AGAINST IMPACT DEPRESSURIZATION AND WAIT FOR RESCUE.
3. CONTROL FLOOD FLOW RATE TO ALWAYS DEMAND MAINTENANCE OF 8 PSIA OR GREATER FOR 20 MINUTES (TO PERMIT LONG-STAY CONFIG. SUIT DON)
   - SIZE LINES FOR 450 pph MAX. FLOOD FLOW RATE
   - RETAIN EMERGENCY GAS CAPACITY REQUIRED BY SHIRTSLEEVES RE-ENTRY
   - USE O_2 MASKS
   - THIS WILL PROVIDE FOR SAFE SUIT DON TO APPROXIMATELY 1" HOLE
4. INSTRUMENT FOR:
   - LEAK ALARM
   - LEAK RATE INDICATOR (FOR DECISION ON RETURN MODE, SUITS)
   - IMPACT DETECTOR (TO WARN AGAINST POTENTIAL EXTERNAL DAMAGE)

Rev.

PRELIMINARY EMERGENCY SYSTEM (CONT'D)

5. DIRECT EGRESS FROM ATTACHED MODULE TO CABIN (VIA AIRLOCK USE) FOR MODULE LEAK; USE OXYGEN MASKS
   - QUICKEST OPTION TO SAFETY
   - NO FLOOD FLOW TO MODULES OF CURRENT SIZES IS REQUIRED
6. PROVIDE AVIONICS CAPABILITY TO STABILIZE ON ORBIT FOR RESCUE WITH DEPRESSURIZED CABIN

CONTAMINATED ATMOSPHERE

7. DEPRESS/REPRESS CABIN CAPABILITY SHOULD BE PROVIDED (ALTERNATE ECS SCRUB TO CLEAR SMOKE)
   - DON SUITS AND REMAIN IN CABIN
   - OXYGEN MASKS
8. CONTAMINATED MODULE:
   - OXYGEN MASKS
   - EGRESS TO AIRLOCK, PURGE AIRLOCK
   - THEN EGRESS TO CABIN
   - PAYLOAD OPTIONAL : DEPRESS/REPRESS MODULE
9. PORTABLE FIRE EXTINGUISHERS IN CABIN AND MODULE

INABILITY TO RE-ENTER

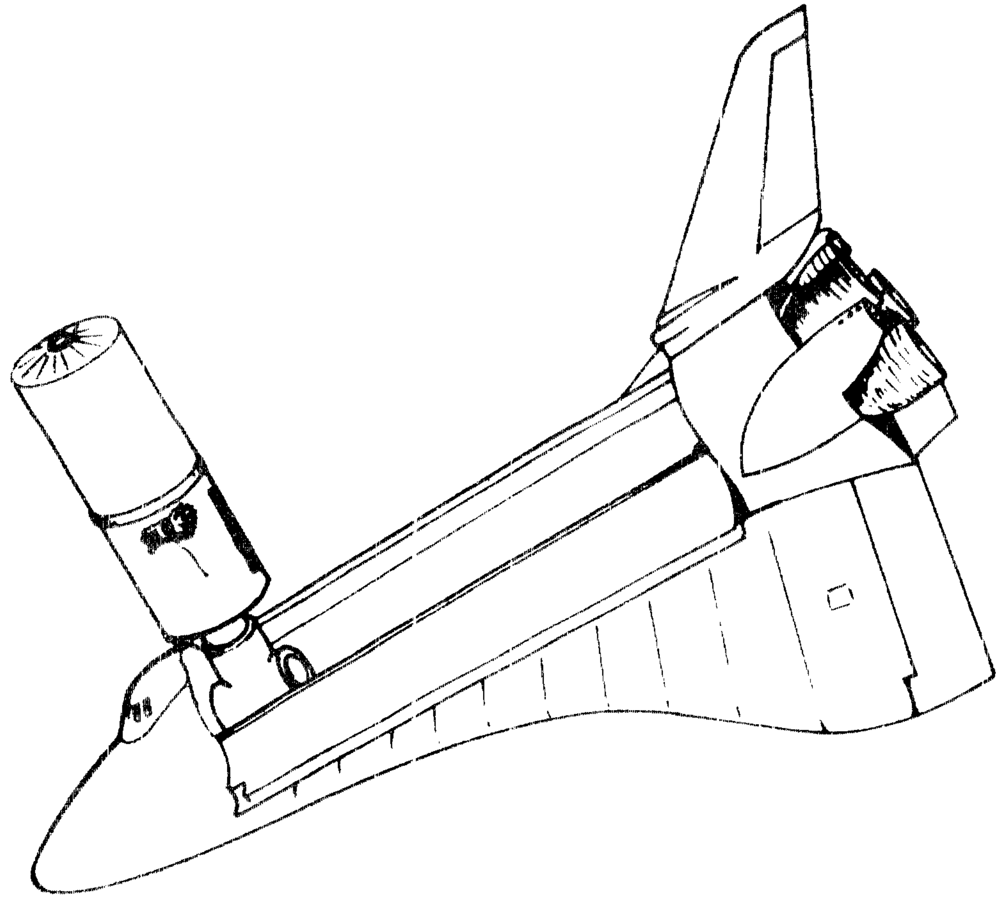
10. PROVIDE EVA CAPABILITY TO INSPECT FOR SAFE RE-ENTRY, CONDUCT MINOR REPAIRS, AND PROVIDE BACK-UP TO CRITICAL SEQUENCES
11. RESCUE SHUTTLE AND CONTINGENCY TRANSFER
12. ESCAPE CAPSULE ON DEVELOPMENT FLIGHTS

Rev.

PRELIMINARY EMERGENCY SYSTEM (CONT'D)

STRANDED CREWMAN

13. DESIGN HATCHES, AIRLOCK SYSTEMS, AND EXPERIMENTS TO ACCEPTABLE RISK OF NO BLOCKED ACCESS
14. OPERATE WITH ALL CONNECTING HATCHES OPEN, AIRLOCK/CABIN HATCH CLOSED
15. PROVIDE STANDBY-IN-CABIN EVA RESCUE CAPABILITY



SUPPLEMENTARY BRIEFING EMERGENCIES

PRESENTED TO

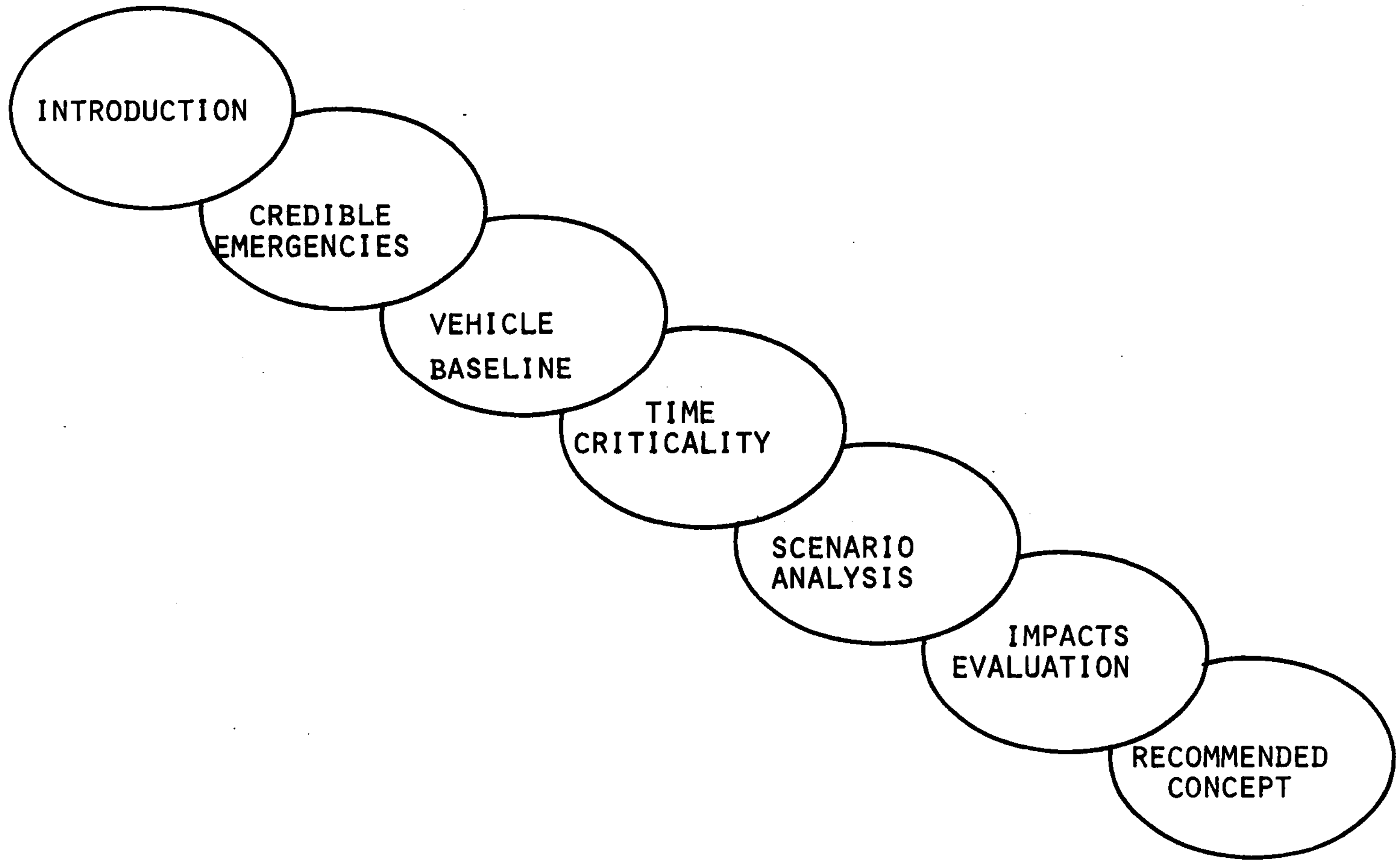
NASA-JSC

13 MARCH 1973

This briefing was initially presented at NASA-JSC on 13 March 1973. Certain corrections and additions have been made since that time for the sake of accuracy and completeness - changed pages are so marked. Additional delta-studies were also conducted, and are the subject of the previous section containing the April briefing. Those changes are not incorporated herein. Any conflicts in the two briefings should be taken in favor of the April briefing.

Rev.

OUTLINE


INTRODUCTION
CREDIBLE EMERGENCIES
VEHICLE BASELINE
TIME CRITICALITY
SCENARIO ANALYSIS
IMPACTS EVALUATION
RECOMMENDED CONCEPT

INTRODUCTION

- ISSUES
- OBJECTIVES
- METHODOLOGY

EMERGENCY ISSUES

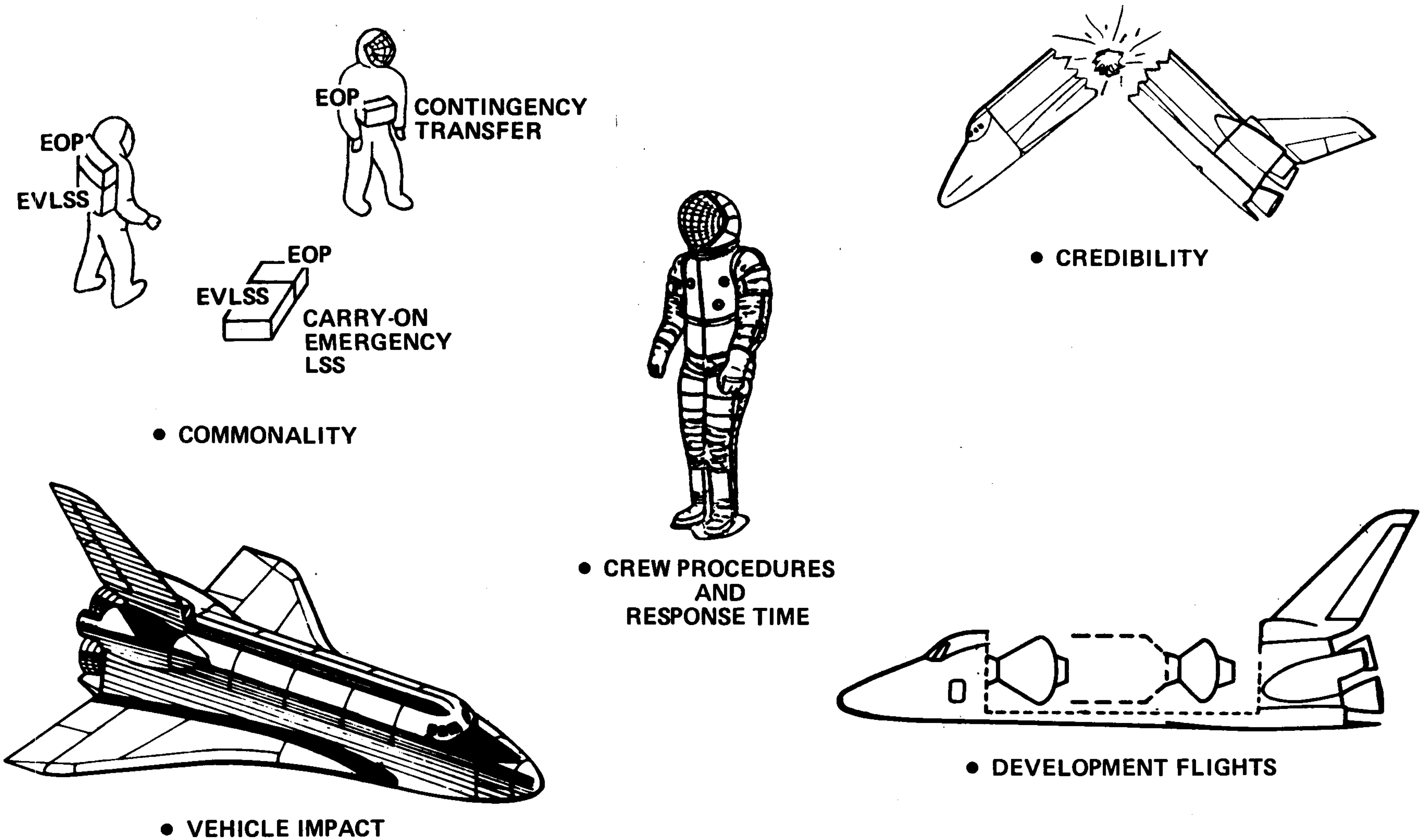
An aim of the present study has been to define an overall emergency concept with maximum flexibility to accommodate an evolving design. The opposing chart illustrates some of the most important issues in arriving at the concept. Other issues, such as use of current technology hardware, are also important.

Development flights present some special considerations. During this phase, an orbital rescue capability by a second shuttle will not be available. Also, in general, hazards will be greater. The issue presents itself of whether to accept the higher risks during this period, or to provide additional emergency equipment. The current study has attempted to identify requirements for this special emergency equipment.

Groundrules loosely applied in evaluating emergency situations and concepts included:

- No Dual Contingencies
- No Major Modifications To The Orbiter Configuration (such as refuge chambers)
- Consider All Viable Emergencies
- On-Orbit Rescue Is Feasible During The Operational Phase Of The Orbiter

EMERGENCY ISSUES



OBJECTIVES

DETERMINE FUNCTIONAL REQUIREMENTS

- INTERFACES
- EQUIPMENT
- TIME CRITICALITY

EVALUATE ALTERNATIVES FOR SYSTEM IMPACTS

- ORBITER CAN RE-ENTER UNPRESSURIZED
- BLOCKED CABIN ACCESS
- DEVELOPMENT FLIGHTS
- EMERGENCY LSS'S

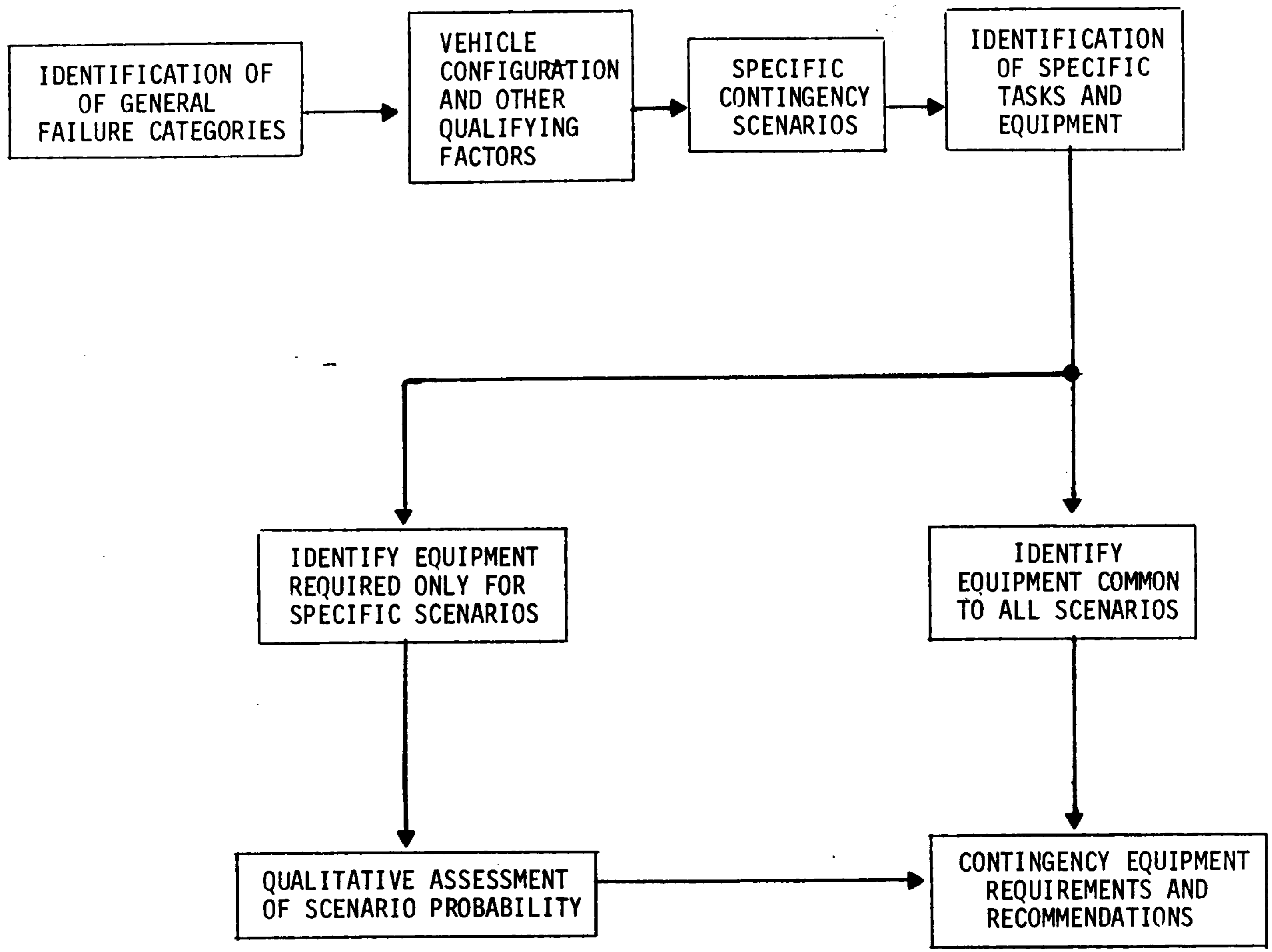
ESTABLISH AN EMERGENCY CONCEPT

- EMERGENCIES NOT INCLUDED IN PRR ORBITER
- ACCEPTABLE SAFETY
- COMMONALITY
- BASIS FOR LATER OPTIMIZATION
- BASIS FOR EVALUATION OF ORBITER CHANGES

METHODOLY FOR
EMERGENCY EQUIPMENT SELECTION LOGIC

First the general categories of credible failures that can occur during shuttle and related operations were identified. These categories were further divided to allow the identification of specific scenarios requiring EVA/IVA equipment or action.

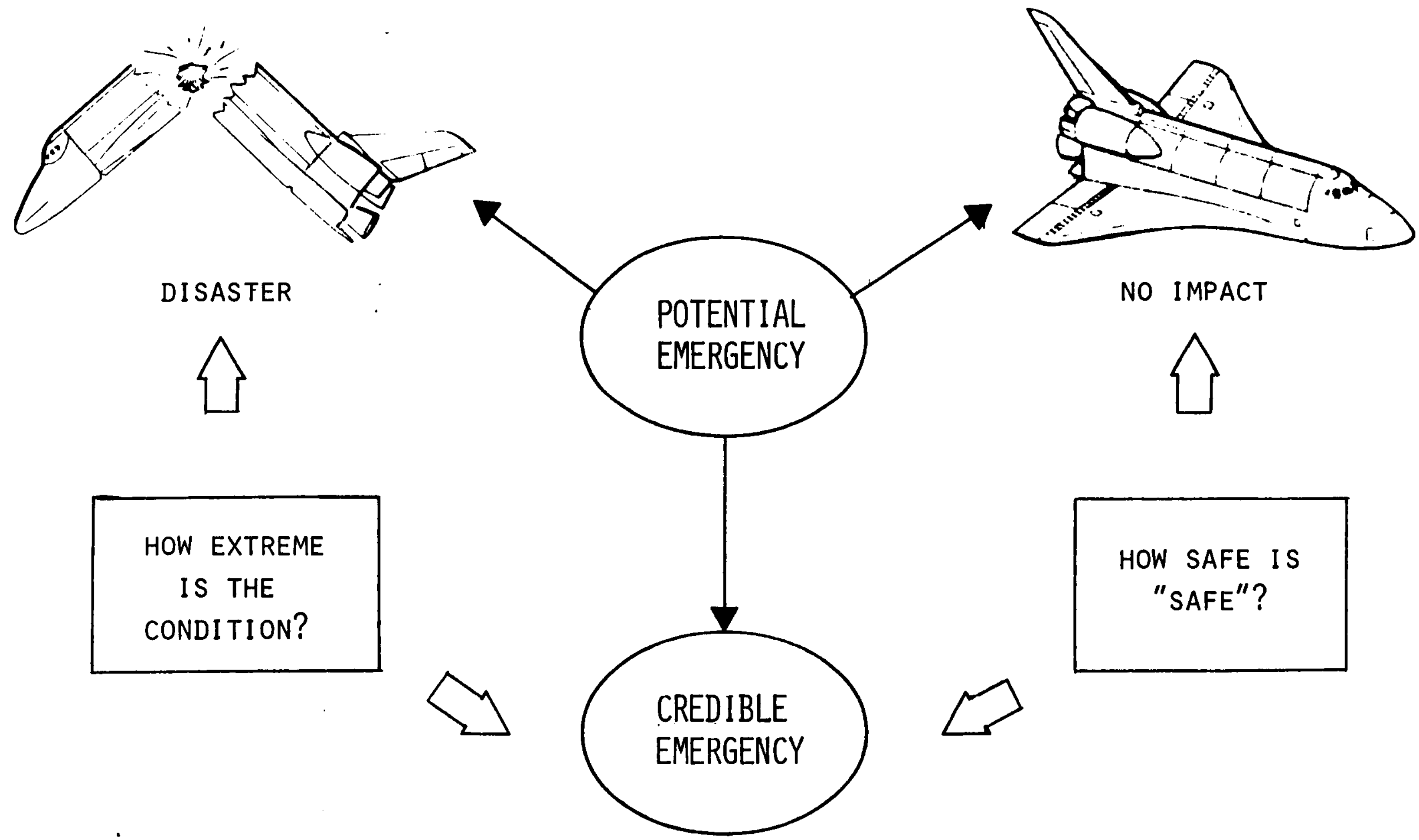
Following the identification of the contingency tasks and equipment for each scenario, the equipment that is common to all scenarios was identified. The equipment required only for particular scenarios are included in the final contingency recommendations as an option if an assessment of that scenario's probability of occurrence indicates that it is not likely to occur, or can be reduced to an acceptable risk by design.


IDENTIFICATION OF OF GENERAL FAILURE CATEGORIES
VEHICLE CONFIGURATION AND OTHER QUALIFYING FACTORS
SPECIFIC CONTINGENCY SCENARIOS
IDENTIFICATION OF SPECIFIC TASKS AND EQUIPMENT
IDENTIFY EQUIPMENT REQUIRED ONLY FOR SPECIFIC SCENARIOS
IDENTIFY EQUIPMENT COMMON TO ALL SCENARIOS
QUALITATIVE ASSESSMENT OF SCENARIO PROBABILITY
CONTINGENCY EQUIPMENT REQUIREMENTS AND RECOMMENDATIONS

CREDIBLE EMERGENCIES

- CREDIBILITY
- SUMMARY OF CREDIBLE EMERGENCIES
- EXAMPLE EMERGENCIES
- DECOMPRESSION CREDIBILITY

CREDIBILITY



CREDIBLE EMERGENCIES

Eight classes of credible emergencies with a potential requirement for EVA/IVA equipment or action were identified during the Tasks, Guidelines and Constraints phase of this study. Major sources of information were the Aerospace, Rockwell, and RAM safety studies, as well as identification of potential contingency situations by VSD. The degree of credibility of each emergency is, of course, highly dependent on vehicle design, and the option often exists for designing to an acceptable risk level. It is expected that as the basic orbiter and Sortie Lab FMEA and safety studies progress, the credibility of some of the contingencies will be modified.

The opposing chart lists the eight classifications. The classes do not indicate a sequence of estimated importance or credibility. Additional detail on the listed emergencies will be given on the following charts.

SUMMARY OF CREDIBLE EMERGENCIES

CLASS I	FIRE OR RELEASE OF TOXIC SUBSTANCES
CLASS II	EXPLOSION
CLASS III	DECOMPRESSION OF PRESSURIZED COMPARTMENT
CLASS IV	INTERNAL HATCH FAILURE OR BLOCKED ACCESS PATH
CLASS V	FAILURE TO DOCK/UNDOCK
CLASS VI	FAILURE OF AIRLOCK OR OTHER EXTERNAL HATCH
CLASS VII	INSPECT/REPAIR SHUTTLE EXTERNAL DAMAGE
CLASS VIII	RESCUE DISABLED EVA/IVA CREWMAN

CLASS I - FIRE OR RELEASE OF TOXIC SUBSTANCES

A fire or release of toxic substances could occur in the orbiter cabin, a manned experiment module, the unpressurized cargo bay, or a docked freeflyer. Fires could be caused by a variety of sources such as electrical discharge, short circuits, chemical reactions, or open flames. Most fires would produce toxic byproducts but other sources of toxic material include cryogen spills, propellant leakage, and experimental chemicals*. The cases chosen for illustration are a fire in the cabin or in a manned experiment module.

Contingency scenarios were defined, detailed timelines established, and emergency equipment requirements determined for the following five emergencies chosen as representative.

I-a	Fire contaminates cabin
I-a-A	• Re-enter with contamination
I-a-B	• Depressurize and repressurize first
I-b	Fire in unpressurized cargo bay
I-c	Fire in manned sortie module
I-c-A	• Cabin affected
I-c-B	• Cabin not affected

* It is estimated that about 37% of the flights in the October 1972 NASA-JSC Traffice Model would involve potentially hazardous sortie and servicing activities which could release toxic materials. A secondary effect of the release of toxic materials is the obstruction of vision by smoke/fumes.

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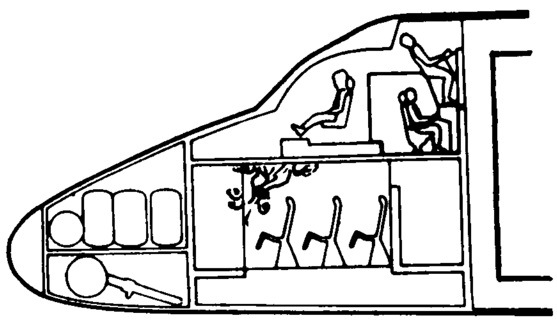
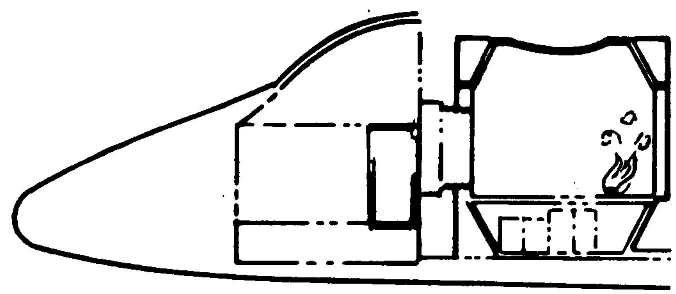
EXAMPLE CLASS I EMERGENCY
FIRE OR RELEASE OF TOXIC SUBSTANCES



ORBITER CABIN



MANNED EXPERIMENT MODULE

CLASS II - EXPLOSION

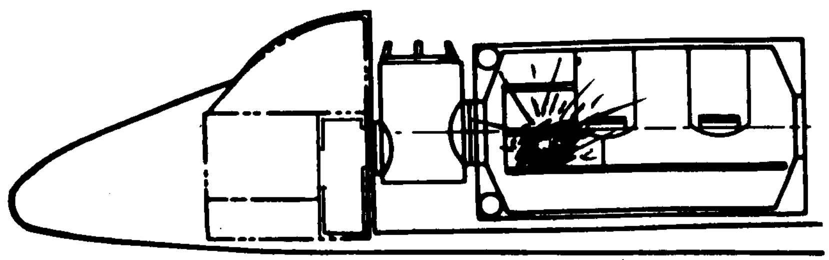
An explosion could occur in many locations in the shuttle orbiter. However, the most likely locations are in the cargo bay, a docked free-flyer, or in an attached experiment module. The case of an explosion in the shuttle pressure cabin is probably unlikely, but it is included, since if it did occur, it would require immediate emergency action to save the crew. An explosion could be followed by almost any other type of emergency situation, although some combinations are less credible than others.

Contingency scenarios were defined, detailed timelines established, and emergency equipment requirements determined for the following four emergencies chosen as representative:

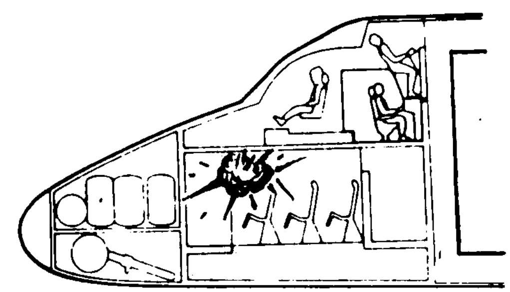
- II-a Explosion in cabin; shuttle cannot re-enter
  - II-a-A • Depressurize and repressurize cabin; await rescue
  - II-a-B • Await rescue with contaminated cabin
- II-b Explosion in sortie module; blocked access to cabin
- II-c Explosion in sortie module, with decompression (no blocked access)

EXAMPLE CLASS II EMERGENCY

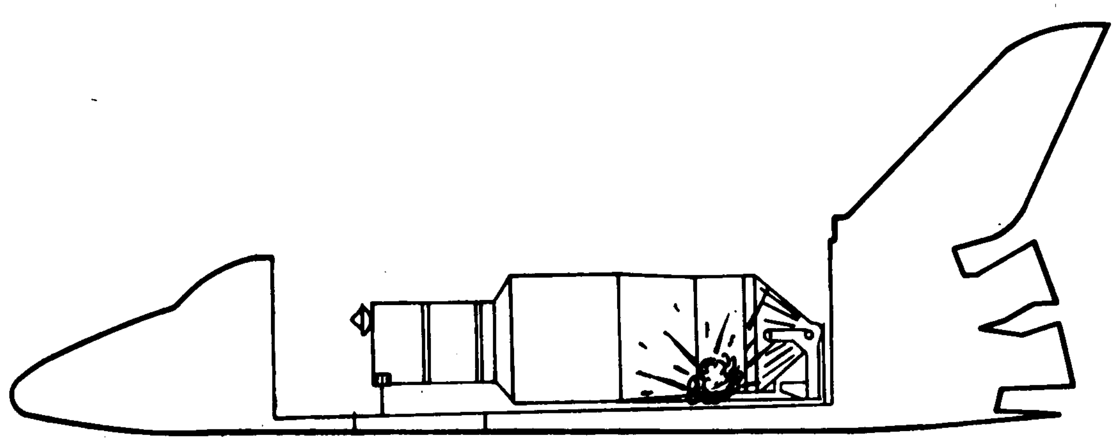
EXPLOSION



SORTIE MODULE



ORBITER CABIN



UNPRESSURIZED CARGO BAY

CLASS III - DECOMPRESSION

The scenario chosen for illustration here is the case of slow decompression of the orbiter cabin. The leakage rate is slow enough that there is time for the crewmen to don their suits, if this mode of safing were chosen. Other places a decompression could occur are the airlock, a manned sortie module, a space station module, or a pressurized docked free-flyer during servicing.

Such an occurrence could result from a seal failure (window, airlock hatches, pressure bulkhead feedthroughs, etc.), micrometeoroid impact, structural flow, overboard vent failure, secondary effects from a fire or explosion, or collision damage. The credibility of an accidental decompression is established by considering a recent tabulation of USAF accidental decompressions*, listing 417 occurrences, and a rate of 1335 per 100,000 hours flying above 50,000 ft. In addition, experience with the X-15 has resulted in 24 accidental decompressions out of 199 flights. For a "work horse" vehicle such as the space shuttle, which is designed for use on a variety of missions over a period of years, the finite probability of a decompression requires protective measures.

In the current study it was mutually agreed with the Technical Monitor that an explosive decompression would not be considered credible, as such an occurrence would likely be a disaster anyway. Rapid decompressions were included, however.

Also by mutual agreement with the Technical Monitor, three basic orbiter capabilities were considered in the decompression analysis: (1) the orbiter can re-enter unpressurized and crew provisions must support 3 hours of depressurized operation prior to re-entry, (2) same, but 10 hours prior to re-entry, and (3) the orbiter cannot re-enter depressurized, and crew provisions must support 96 hours of depressurized operation prior to on-orbit rescue.

The following five representative contingency scenarios were defined, detailed timelines established, and emergency equipment requirements determined:

III-a	Repairable leak in cabin
III-a-A	• Shuttle cannot re-enter depressurized
III-a-B	• Shuttle can re-enter depressurized
III-b	Unrepairable leak in cabin
III-b-A	• Shuttle cannot re-enter
III-b-B	• Shuttle can re-enter depressurized
III-c	Leak in sortie module

* From: Wilson, C. L., "Re-evaluation of Emergency Pressurization Requirements for Brief Flights Above 50,000 Feet", Aerospace Medicine; February 1971, pp 183-185.

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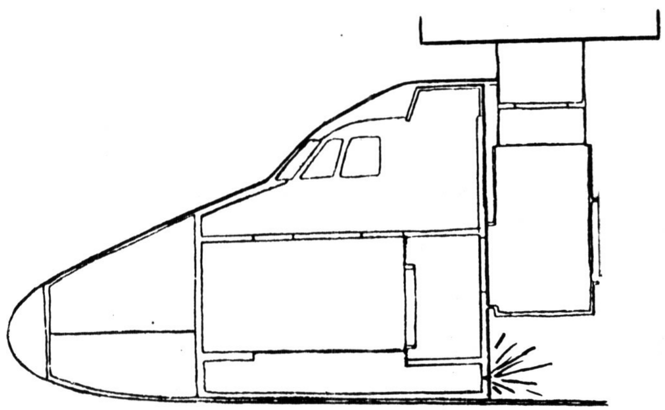
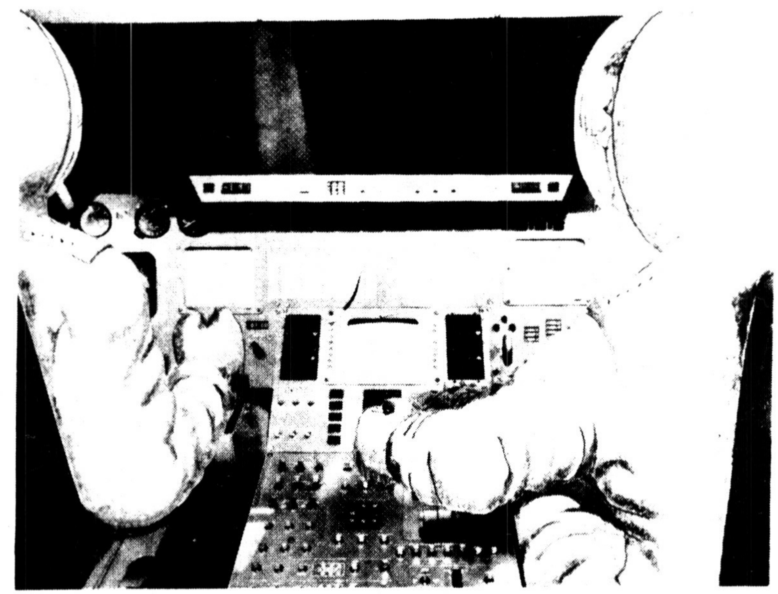
EXAMPLE CLASS III EMERGENCY
DECOMPRESSION



ORBITER CABIN

UNPRESSURIZED
MISSION ABORT



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CLASS IV - INTERNAL HATCH FAILURE OR BLOCKED ACCESS

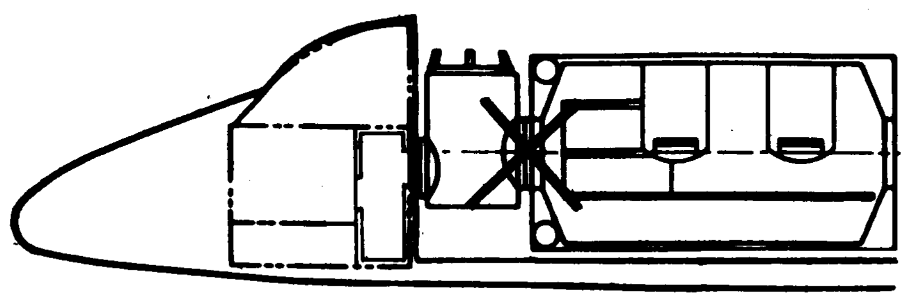
This class of emergencies considers cases by which internal access to the orbiter cabin is blocked, via a hatch failure or some other reason. It is important whenever a crewman is in some other manned pressurized compartment, such as a sortie module or docked free-flyer. The hatch failure can be either one of opening or closing, in such a way that shirtsleeve access to the orbiter cabin is not possible. Current designs of the shuttle and manned modules baseline that the crewmen must ingress the cabin prior to re-entry. The example chosen for illustration is the case of blocked access between the orbiter and a sortie module, with the docking module in place.

A distinguishing geometric factor is whether or not the docking module is present. Three representative contingency scenarios were defined, detailed timelines established, and equipment requirements determined:

IV-a	Docking module not available
IV-a-A	• Manipulator not functional
IV-a-B	• Manipulator as translator
IV-b	Docking module available

EXAMPLE CLASS IV EMERGENCY

INTERNAL HATCH FAILURE OR BLOCKED ACCESS PATH



BLOCKED RETURN FROM SORTIE MODULE

CLASS V - FAILURE TO DOCK/UNDOCK

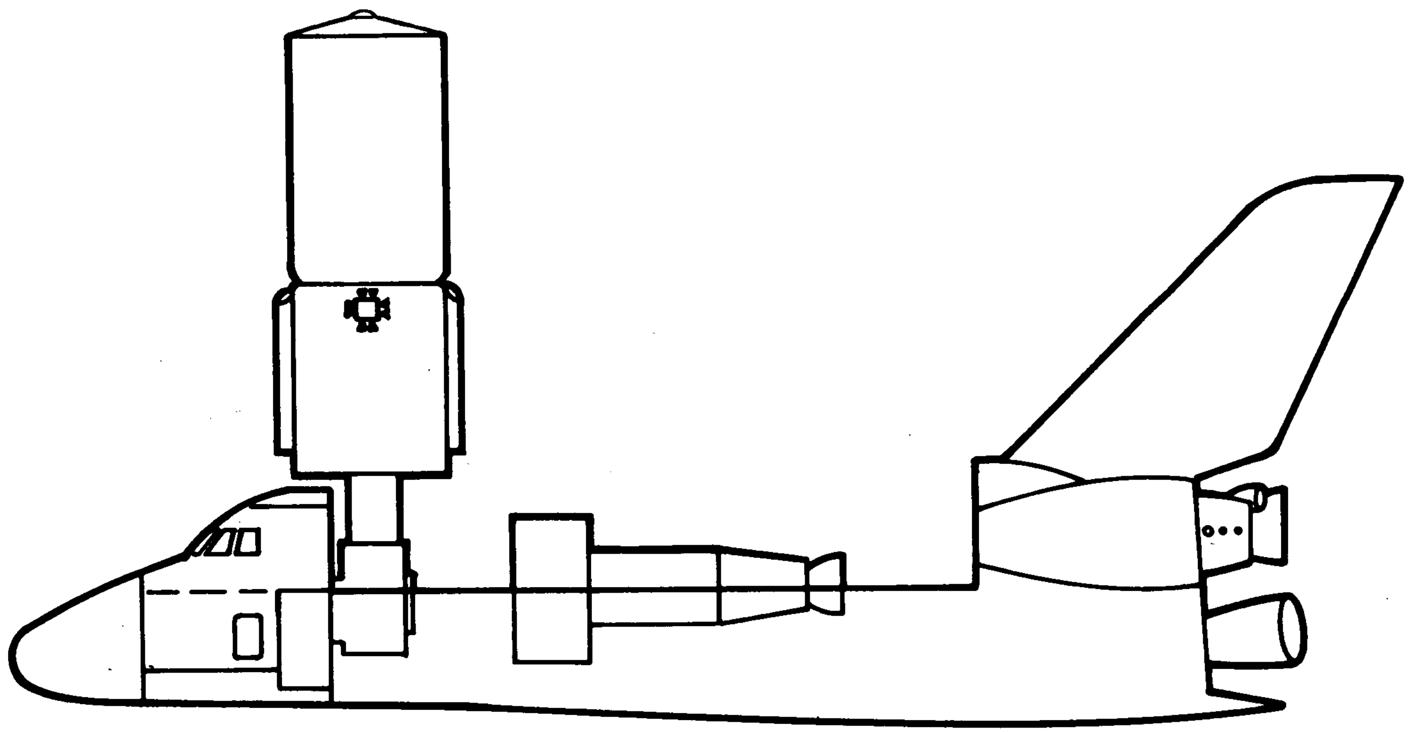
The primary qualifying factors that determine the separate scenarios in this case are whether the failure prevents docking from occurring or whether the failure prevents safe release following docking. In the case of failure to "hard" dock, the case of on-orbit rescue by a second shuttle is of primary interest, although in other missions, such as modular space station personnel rotation, this could also be considered a contingency. Failure of the rescue shuttle to dock with a depressurized orbiter is a particularly viable contingency, as the PRR baseline orbiter design would not have the ability to stabilize in orbit following pressure loss and avionics failure. The illustrated case of failure to undock is also important, as it could prohibit re-entry.

Two representative scenarios were defined, detailed timelines established, and equipment requirements determined:

V-a Failure of rescue shuttle to dock
V-b Failure to undock

EXAMPLE CLASS V EMERGENCY

FAILURE TO DOCK/UNDOCK



ORBITER DOCKED TO LARGE OBSERVATORY

CLASS VI - FAILURE OF AIRLOCK OR OTHER EXTERNAL HATCH

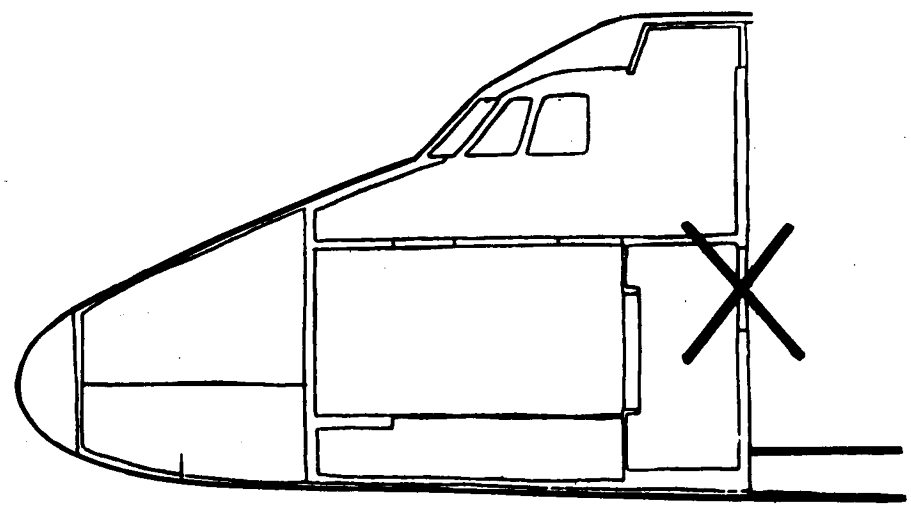
This class of contingency is concerned with failure of an external hatch to open when required or to close and seal. The scenario illustrated is the case of an outer hatch failing to seal when closed following an EVA/IVA.

Other specific examples falling in this class are cabin hatch fail to open, equalization valve failure, EVA hatch fail to open, airlock failure to pressurize, cabin side leak, and EVA hatch failure to close.

Two representative scenarios were defined, detailed timelines established, and equipment requirements determined:

VI-a	EVA hatch fail to seal
VI-b	Hatch to cabin fail to open

EXAMPLE CLASS VI EMERGENCY
FAILURE OF AIRLOCK OR OTHER EXTERNAL HATCH



AIRLOCK HATCH
SEAL FAILURE

CLASS VII - INSPECT/REPAIR SHUTTLE EXTERNAL DAMAGE

This class includes a wide variety of contingencies which can result from a number of causes during ascent or orbital operations. Among the most credible causes are: (1) collision during booster or drop tank separation, docking, cargo manipulation, or with meteoroids or other debris, (2) solid rocket motor case burn-through, (3) secondary damage from explosions in or near the cargo bay, and (4) malfunction of automated systems during payload deployment or retrieval. Rockwell has suggested this latter to be particularly significant, even though the capability to jettison is a design goal. Because of the many in-line operations during such an operation, an EVA level of redundancy is highly desirable.

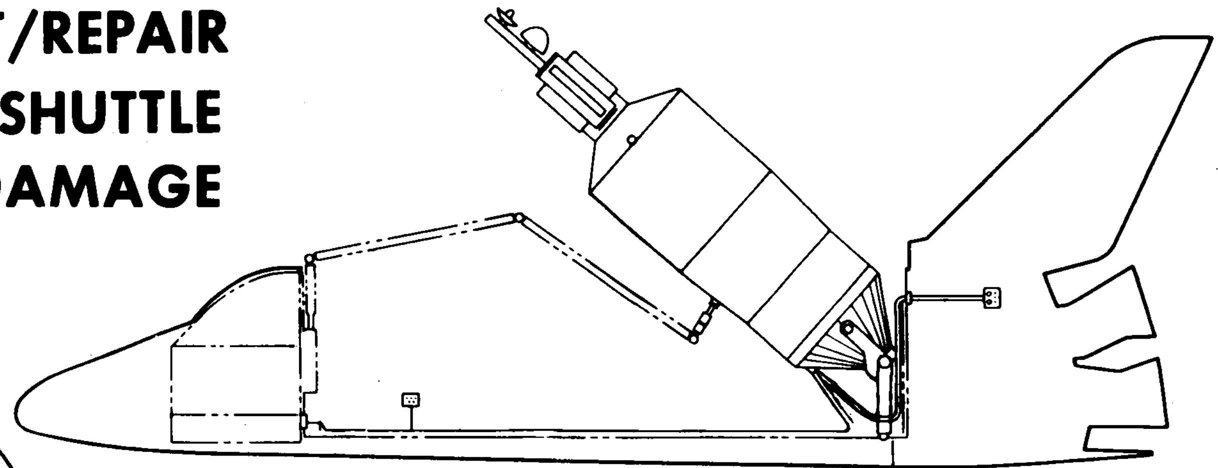
Thermal Protection System (TPS) damage inspection was chosen for definition as a representative scenario, a detailed timeline was established, and equipment requirements were determined:

VII-a TPS inspection

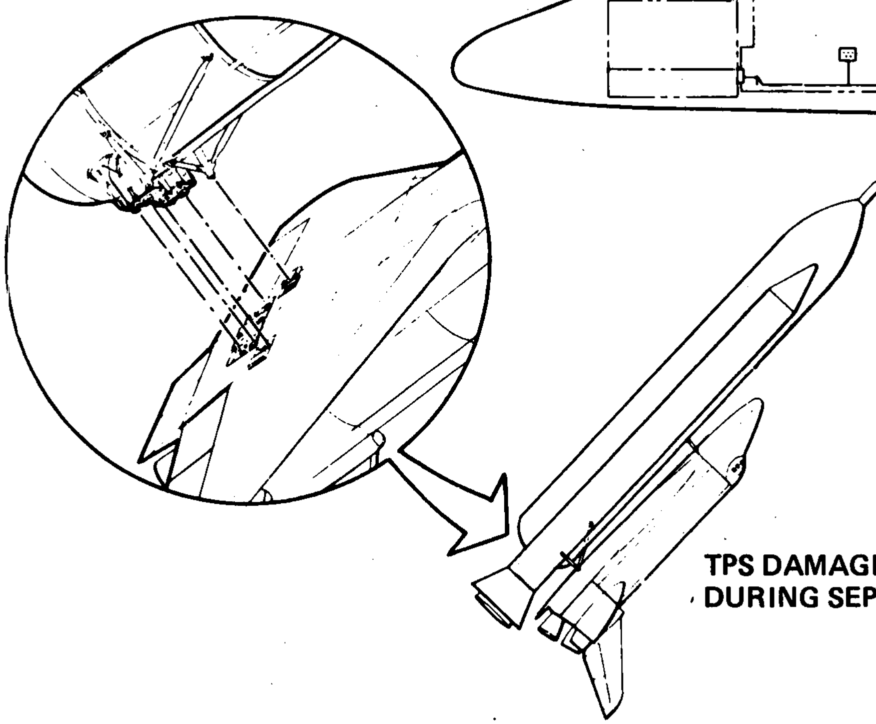
The representative Class II scenario of explosion in the cargo bay also serves as representative of tasks to be accomplished inspecting/repairing cargo bay damage listed here.

EXAMPLE CLASS VII EMERGENCY

INSPECT/REPAIR SHUTTLE EXTERNAL DAMAGE



CARGO BAY DAMAGE
DURING PAYLOAD HANDLING



TPS DAMAGE
DURING SEPARATION

CLASS VIII - DISABLED EVA/IVA CREWMAN

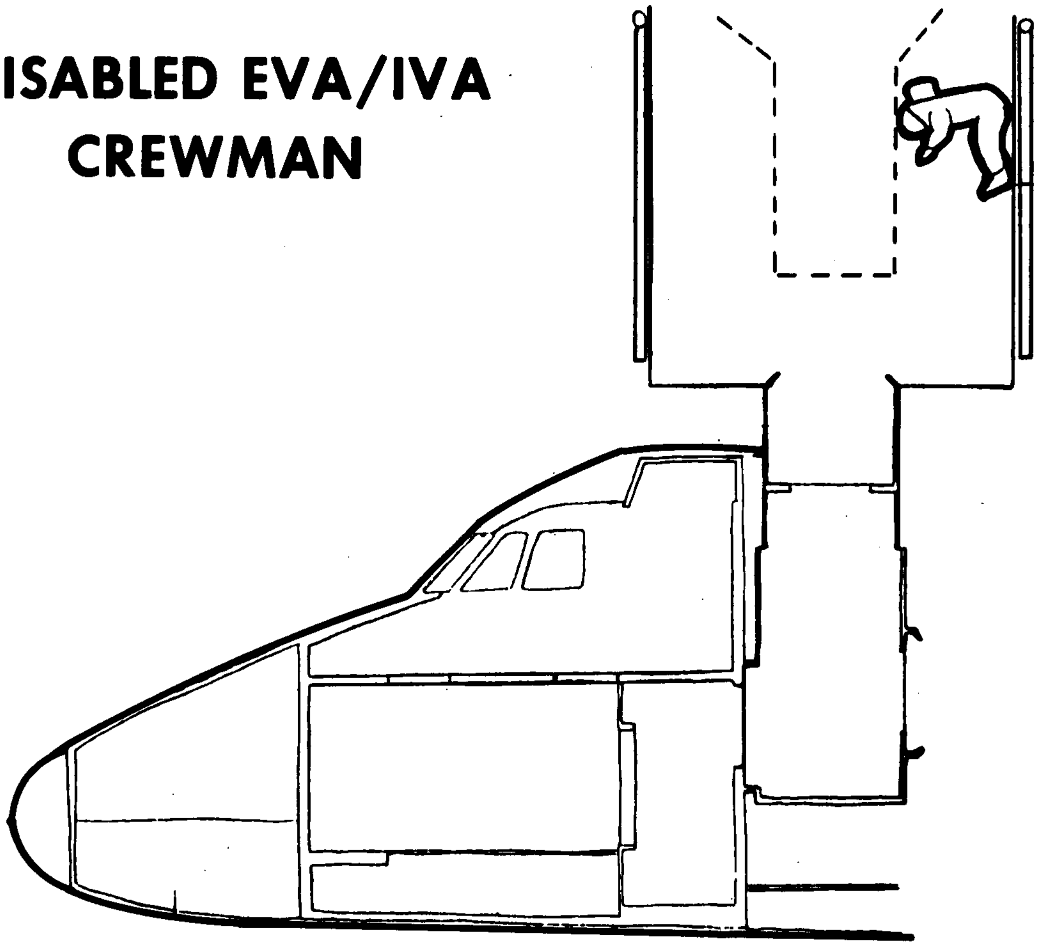
The primary distinguishing factors that define the scenarios in this case are whether or not the disabled crewman is conducting EVA or IVA, whether or not 2 men are involved in the EVA/IVA, and, in the case of EVA, whether or not he is in physical contact with the orbiter. The illustrated scenario is the case of a disabled or unconscious IVA crewman servicing a docked large observatory.

Some causes of crewman disability could be illness, extravehicular life support system failure, suit leak, or manipulator failure. Six scenarios selected as representative for detailed analysis, timelines, and equipment requirements determination are:

VIII-a	Disabled, drifted EVA crewman
VIII-a-A	• Two man EVA
VIII-a-B	• One man EVA
VIII-b	Manipulator malfunction/disabled crewman
VIII-b-A	• Two man EVA
VIII-b-B	• One man EVA
VIII-c	Disabled IVA crewman
VIII-c-A	• Two man IVA
VIII-c-B	• One man IVA

EXAMPLE CLASS VIII EMERGENCY

DISABLED EVA/IVA CREWMAN



UNPRESSURIZED
IVA SERVICING
MISSION

DECOMPRESSION CREDIBILITY

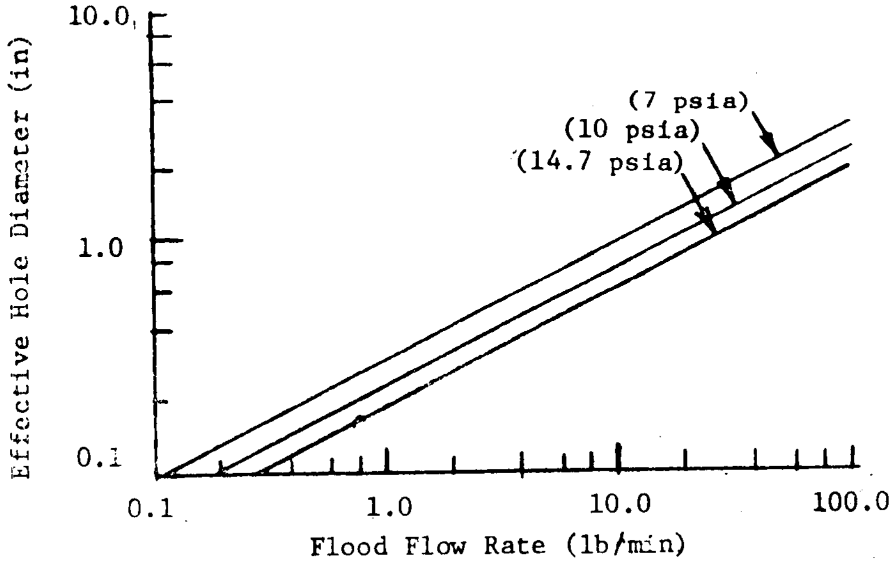
Selected USAF Aircraft Decompression experience is presented below:

TYPE AIRCRAFT	TOTAL NUMBER OF ACCIDENTAL DECOMPRESSIONS (ALL ALTITUDES)	ACCIDENTAL DECOMPRESSION RATE PER 100,000 HOURS FLYING ABOVE 50,000 FT
B-57-F	15	35
F-101	29	0
F-102	28	0
F-104	8	0
F-106	9	-
U-2	311	1300
X-1	1	-
X-15	16	-

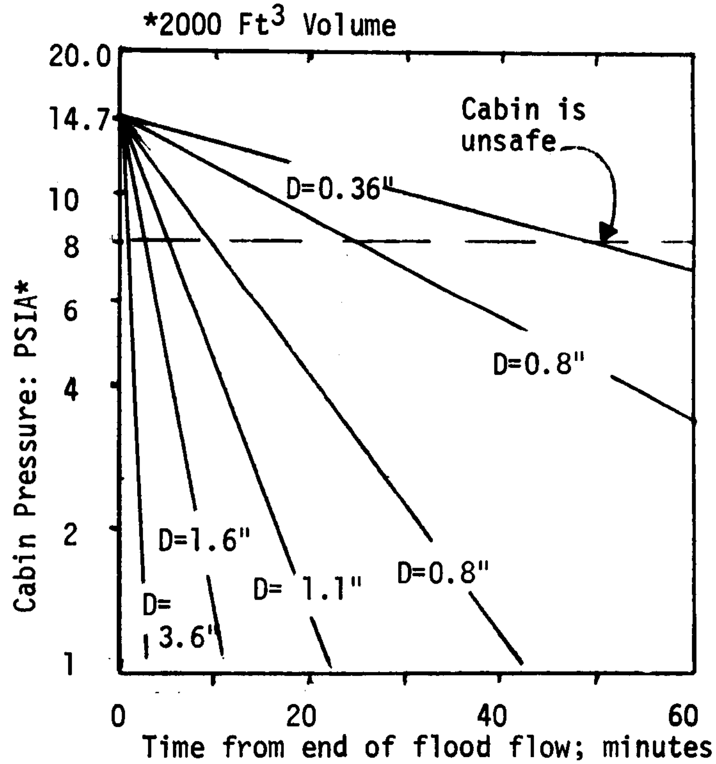
From: Wilson, C. L., "Re-evaluation of Emergency Pressurization Requirements for Brief Flights Above 50,000 Feet"; Aerospace Medicine; February 1971., pp 183-185.

The most significant parameter in determining the decompression period is the maximum credible hole size. Once this quantity has been determined the time of flood flow is calculated by subtracting the cabin decay time to an unsafe level from the time required to reach safety. The rate of flood flow is determined directly from the hole size. The quantity of reserve gas is simply the product of the rate and time.

DECOMPRESSION CREDIBILITY



ATMOSPHERE FLOOE FLOW RATE VS. HOLE SIZE



CABIN PRESSURE DECAY

VEHICLE BASELINE

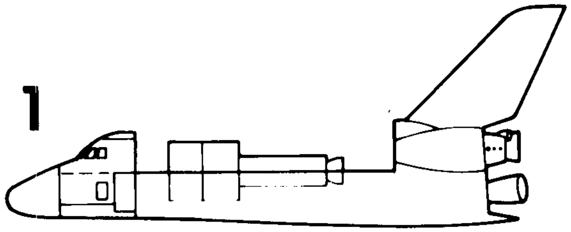
- CONFIGURATIONS
- ORBITER BASELINE
- SORTIE LAB

VEHICLE CONFIGURATIONS

The opposing chart illustrates the discrete functional configurations associated with the Rockwell PRR baseline. The distinguishing factors are manned access routes from the orbiter cabin and docked manned payloads. It should be noted that the old flex-tunnel module deployment is included in Configuration No. 3. While the sketches are specific to the PRR baseline, it is believed that the results of the emergency analysis will apply to any foreseeable modifications to these configurations.

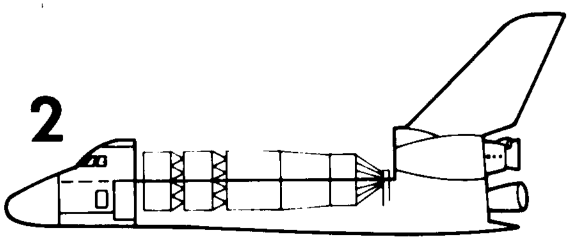
VEHICLE CONFIGURATIONS

1



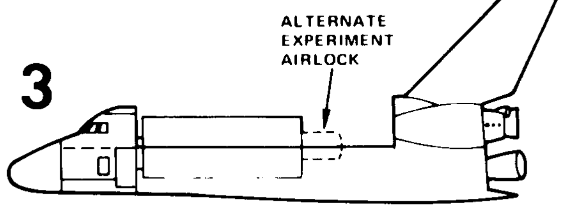
- NO DOCKING MODULE
- UNBLOCKED ACCESS TO AIRLOCK
- NO SORTIE MODULE

2



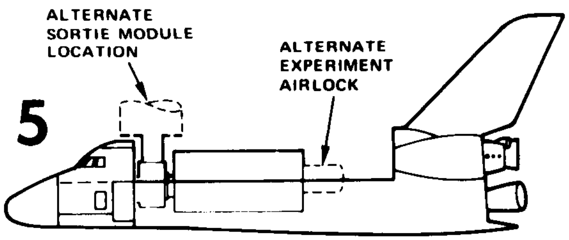
- NO DOCKING MODULE
- EVA ACCESS TO AIRLOCK BLOCKED
- NO SORTIE MODULE

3



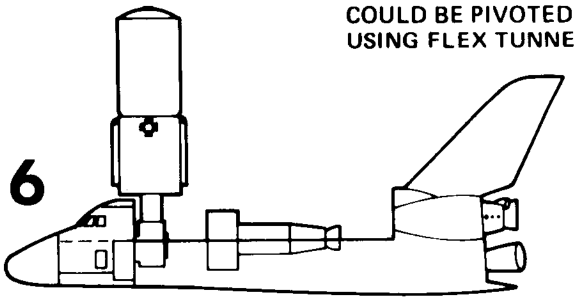
- NO DOCKING MODULE
- EVA ACCESS TO AIRLOCK BLOCKED
- SORTIE MODULE IN PLACE (EQUIVALENTLY COULD BE PIVOTED FROM PAYLOAD BAY USING FLEX TUNNEL)

5



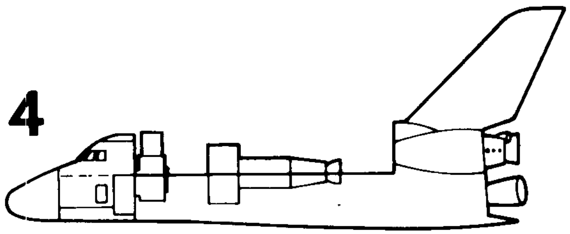
- DOCKING MODULE IN PLACE
- EVA ACCESS TO AIRLOCK THROUGH DOCKING MODULE
- SORTIE MODULE IN PLACE (EQUIVALENTLY COULD BE DOCKED TO TOP OF DOCKING MODULE)

6



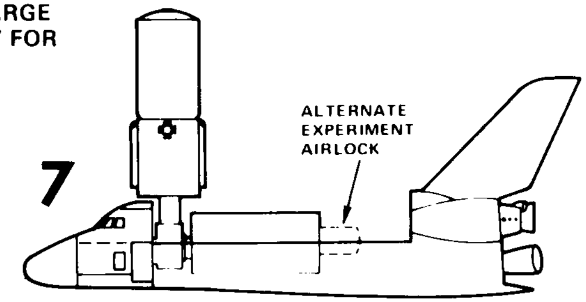
- DOCKING MODULE IN PLACE
- EVA ACCESS TO AIRLOCK THROUGH DOCKING MODULE
- NO SORTIE MODULE
- DOCKED TO LARGE OBSERVATORY FOR SERVICING

4



- DOCKING MODULE IN PLACE
- EVA ACCESS TO AIRLOCK THROUGH DOCKING MODULE
- NO SORTIE MODULE

7



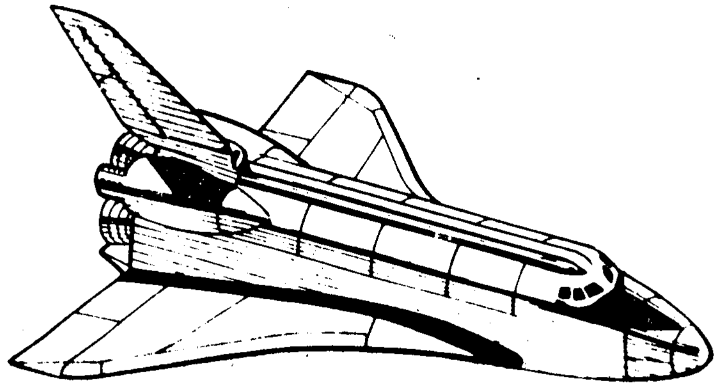
- DOCKING MODULE IN PLACE
- EVA ACCESS TO AIRLOCK BLOCKED
- SORTIE MODULE IN PLACE
- DOCKED TO LARGE OBSERVATORY FOR SERVICING

BASELINE ORBITER

The orbiter characteristics listed are basically those of the Preliminary Requirements Review (PRR) configuration, established in October 1972, with changes obtained by personal communications with NASA-JSC and Rockwell International.

The use of aircooled Avionics on the orbiter results in the inability of the orbiter to re-enter unpressurized, the inability to operate the manipulator with a depressurized cabin, and the inability to actively stabilize the orbiter while depressurized. This latter condition could also prevent on-orbit rescue, although the expected tumbling rate resulting from a depressurization (with no large force applications) would be fairly low, and probably would not preclude the rescue. Although the baseline orbiter cannot re-enter depressurized, the case of including this capability was also investigated in the present study to determine the impact on emergency system requirements.

ORBITER BASELINE



1) 96 hour Cont. LSS with pressurized cabin (rescue shuttle in 96 hrs)
2) 1 hr flood flow @ 150 lb/hr, one cabin change (automatic on low cabin pressure, can initiate by manually open relief valve)
3) 4 gas masks, military A-21 system with 10 min portable O_2 supply & capability to plug into vehicle emergency oxygen
4) Airlock (63" dia x 82" long)
5) Docking module as carry-on
6) Minimum crew size = 2
7) Up to 10 crew and passengers
8) Redundancy in ECLSS and power generation equipment
9) Shuttle can <u>not</u> reenter unpressurized
10) Manipulator can not function with a depressurized cabin
11) Any item which may prevent closure of cargo bay doors can be jettisoned
12) Vehicle can <u>not</u> be stabilized with a depressurized cabin
13) Shuttle can land within 95 min. of a decision (Panic mode)
14) Shuttle can land at a planned landing site in 810 minutes
15) Carry-on 15 second emergency airlock repressurization (to 3.25 psia)
16) Two cabin egress hatches; lower deck hatch sealed closed
17) 4 portable foam-type fire extinguishers plus automatic 6% freon flood in avionics bays
18) C&W sensors for: fire, cabin total pressure, O_2 and CO_2 partial pressure, cabin fluid loop temperature
19) Airlock purge capability

Rev.

SORTIE LAB

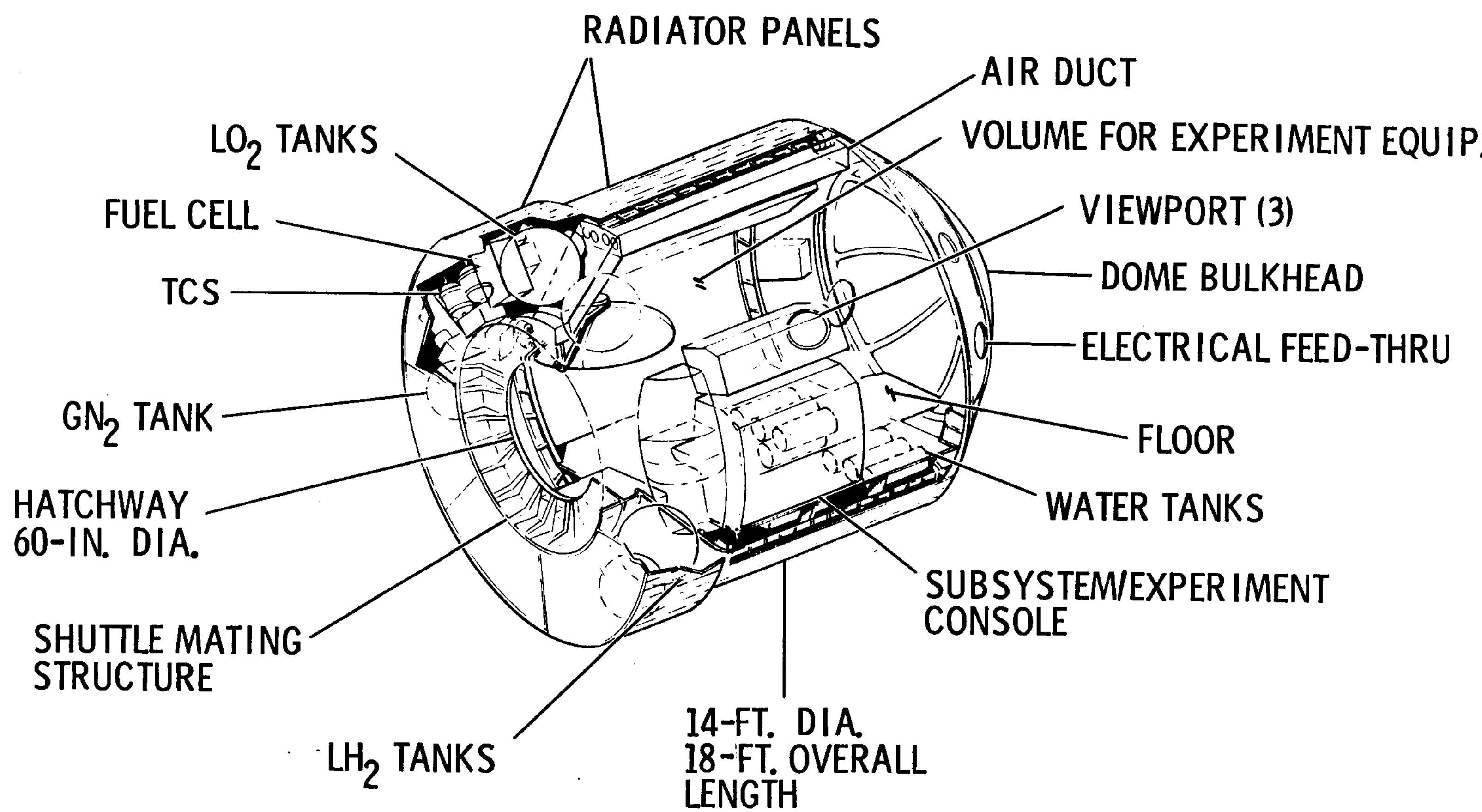
Baseline information on the Sortie Lab were obtained from the Phase B Research and Applications Module (RAM) study documentation and consultation with General Dynamics. This was supplemented by subsequent NASA study results on the Sortie Can* and Sortie Lab **. These latter studies are basically a departure from the RAM design to consider evolving payload and mission requirements, and are directed primarily toward early and austere applications. The basic module configuration and major subsystems are similar, although currently less uniquely defined for the Sortie Lab.

Some of the emergency/safety related aspects of the RAM design are two IV suits, two 10-ft umbilicals, two 30-ft umbilicals, two oxygen masks with 45-minute portable oxygen supplies, one fire extinguisher, and one portable light located in the basic Sortie RAM. The EC/LSS provides purge oxygen flow for an open suit flow loop. In addition an emergency intercom and caution and warning displays and tone are provided. Common to both the RAM and Sortie Lab designs is only a single-egress capability (i.e., only one exit hatch/path for emergency egress). An exception to this is the case of an experiment airlock in the aft end of the module. The RAM system also includes the capability to stack modules; a Ram Support Module (RSM) can be added between the Sortie RAM payload module and the orbiter cabin. In addition, a 32 ft. payload module is available in the system. The RAM safety studies recommend that all RAM internal hatches be positioned open during manned occupancy. The orbiter cabin-to-airlock hatch would be closed.

* "Sortie Can Conceptual Design", NASA-MSFC Program Development Advanced Studies Report No. ASR-PD-DO-72-2, March 1, 1972.

** "Sortie Lab Program Review", First Phase B Review, NASA-MSFC, November 16, 1972.

SORTIE LAB



RAM ILLUSTRATED

TIME CRITICALITY

- OPTIMUM DONNING RATES
- IV SUIT BEST DONNING TIMES
- PGA BEST DONNING TIMES
- HELMET AND GLOVES BEST DONNING TIMES
- CONTINGENCY EGRESS BEST TIMELINES
- ALERT AND DECISION LOGIC AND TIMES
- CRITICAL RESPONSE TIME SUMMARY
- DECOMPRESSION EMERGENCY SAFING
- DECOMPRESSION RATE CONSIDERATIONS
- APPROACH FOR TIME CRITICAL EMERGENCY ANALYSIS

OPTIMUM DONNING RATES

The donning rates listed on the opposing page were used as the basis for estimating all related donning and doffing times. They represent best-guess numbers from experienced subjects at ILC, both on A7LB and AES suits. The times are for one-g conditions in an unrestricted area with assistance (i.e., parts in hand). Thus the times represent limit-type values and must be modified to account for retrieval of articles (if self-don), inexperience, restricted areas (such as airlock), and zero-g.

OPTIMUM DONNING RATES

WITHOUT ACCESSORIES		ACCESSORIES	
COMMUNICATIONS CARRIER	5 SEC	CWG (DOFF)	5 SEC
LOWER TORSO	15 SEC	FCS	3 SEC
UPPER TORSO	15 SEC	LCG	20 SEC
CONNECTOR (COMM. CARRIER TO SUIT)	2 SEC	BIOBELT	3 SEC
GLOVES (EACH)	5 SEC	UTCA	90 SEC
HELMET	10 SEC	CONNECTOR (BIOHARNESS)	3 SEC
EXTRAVEHICULAR VISOR ASSY.	5 SEC	UTCA HOSE CONNECT	2 SEC
OXYGEN CONNECTORS (EACH)	3 SEC		

IV SUIT BEST DONNING TIMES

The opposing chart is a summary of estimated best donning times for the IV suit in three configurations. The standby case assumes the crewman is partially suited, without helmet and gloves and without gas umbilicals necessarily connected, (i.e., the partially suited crewman should be free to move from one station to another). It also assumes partial preparation has been made toward donning the helmet and gloves. The short stay configuration differs from the long stay case only in the deletion of the FCS and UTCA. It is assumed that these donnings begin from the constant wear garment (CWG) shirtsleeve configuration, and that the CWG is designed suitably for use as the IV suit undergarment. The FCS is donned over the CWG.

The following charts give detail supporting time breakdowns for donning the PGA, helmet, and gloves. In all cases adjustments have been made for unassisted donning, and unstow times have been included. Engineering judgement has been applied to assess these times and other considerations relative to the effect of sequence of donning on donning times, zero-g effects, and cabin space restrictions.

IV SUIT BEST DONNING TIMES

ACTION	TIME (MIN: SEC)		
	STANDBY	SHORT STAY	LONG STAY
UNSTOW AND DON FCS	-	-	0:30
UNSTOW CCA	-	0:03	0:03
DON UTCA (9 SUB-STEPS)	-	-	1:30
DON PGA (12 SUB-STEPS)	-	3:13	3:23
UNSTOW AND DON HELMET	0:10	0:40	0:40
UNSTOW AND DON GLOVES	0:25	1:00	1:00
TOTAL	0:35	4:56	7:06

PGA BEST DONNING TIMES

ACTION	TIME (MIN: SEC)	
	SHORT STAY	LONG STAY
RETRIEVE AND UNSTOW PGA	0:30	0:30
PREPARE PGA FOR DON	0:45	0:45
POSITION LOWER TORSO	0:05	0:05
CONNECT UCTA TO PGA	-	0:10
POSITION CCA INTERIOR WIRING	0:05	0:05
DON UPPER TORSO	0:30	0:30
CONNECT UPPER & LOWER TORSO	0:25	0:25
DON CCA	0:06	0:06
CONNECT CCA TO WIRING	0:03	0:03
CONNECT GAS CONNECTORS	0:06	0:06
TOTAL	3:13	3:23

HELMET AND GLOVES BEST DONNING TIMES

ACTION	TIME (MIN: SEC) IV UNSUITED	IV STANDBY
HELMET		
UNSTOW	0:30	-
POSITION NECKRING LATCH	0:03	0:03
PLACE ON SUIT	0:05	0:05
ENGAGE AND LOCK	0:02	0:02
TOTAL	0:40	0:10
GLOVES		
UNSTOW	0:30	-
POSITION WRIST DISCONNECT LATCH	0:03	-
PLACE ON HAND	0:05	0:05
ENGAGE AND LOCK	0:02	0:02
ADJUST PALM RESTRAINT (IF APPLICABLE)	0:05	0:05
DON OTHER GLOVE	0:15	0:13
TOTAL	1:00	0:25

CONTINGENCY EGRESS BEST TIMELINES

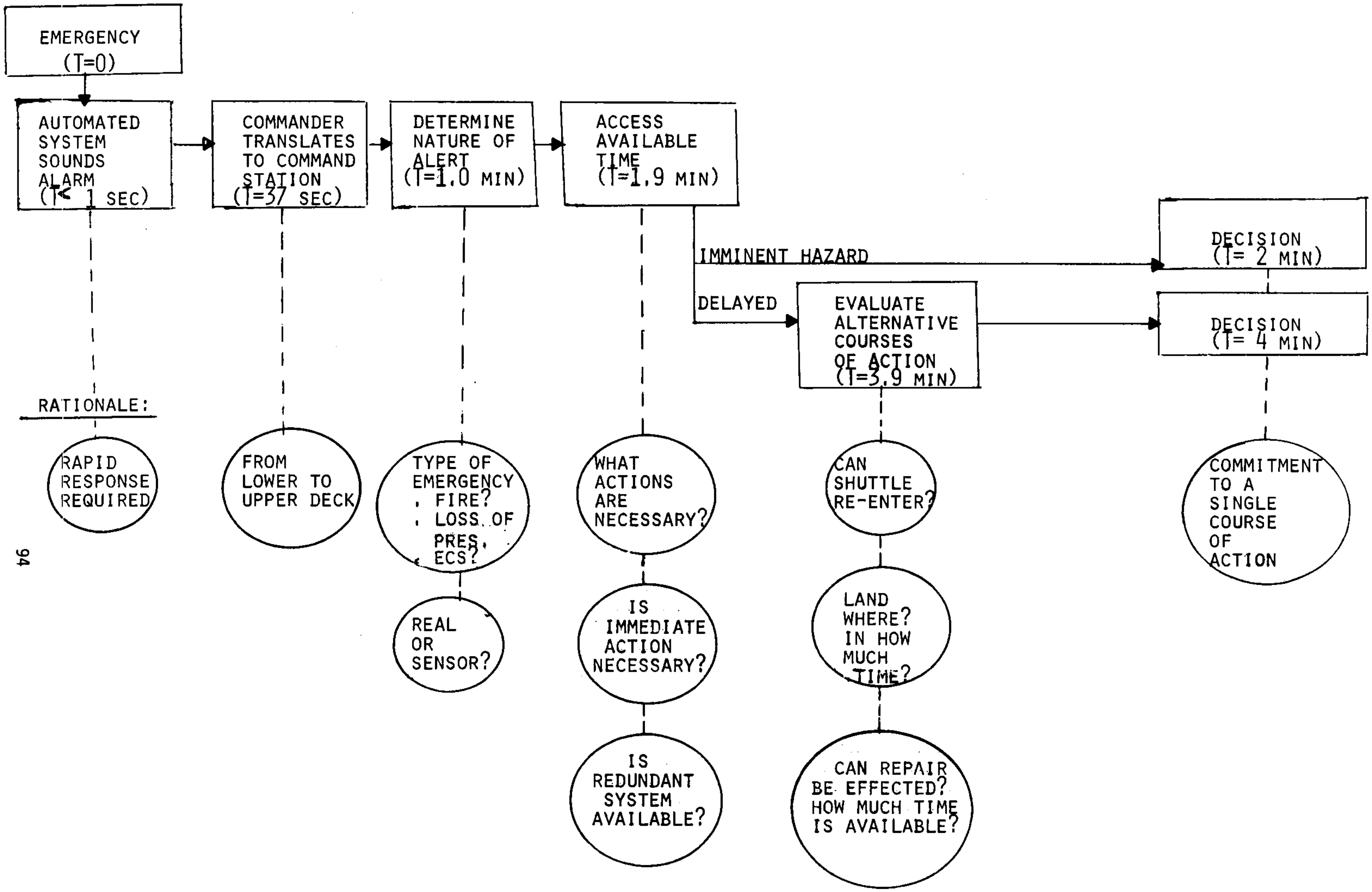
The opposing chart takes the ideal best suit donning times and adds other necessary steps to obtain contingency egress times. As a subsequent chart on Depressurization Emergency Safing will illustrate, various levels of safety are obtained at various points in the sequence. The communications check is not required for safety during the IV donning sequence. Neither is the depressurization time necessarily applicable as chargeable against "getting safe" in the IV emergency case, and is not included in this "best" egress time summation. Corrective action may take place at other than the indicated point in the sequence.

EVA rescue egress times are shown for completeness, although not supported by detailed timelines in this briefing.

CONTINGENCY EGRESS BEST TIMELINES

ACTION	TIME (MIN: SEC)				
	IV EMERGENCY			EVA RESCUE	
	STANDBY	SHORT STAY	LONG STAY	STANDBY	UNSUITED
ALERT & DECISION	2:00	2:00	2:00	2:00	2:00
DONNINGS					
SUIT	0:35	4:56	7:06	0:50	10:13
EVLSS/EOP DON & CHECKOUT	-	-	-	-	8:16
UMBILICAL DON	0:45	0:45	0:45	-	-
ACTIVATE	0:05	0:05	0:05	0:05	0:55
COMM. CHECK	-	-	-	-	0:35
SUBTOTAL	1:25	5:46	7:56	0:55	19:59
CHECKOUT & DEPRESSURIZE					
PRESSURIZE (6 PSI/MIN)	1:20	1:20	1:20	1:20	1:20
INTEGRITY CHECK	0:15	0:15	0:15	0:15	0:15
DEPRESSURIZE (6PSI/MIN)	-	-	-	2:27	2:27
CORRECTIVE ACTION	0:45	0:45	0:45	0:45	0:45
SUBTOTAL	2:20	2:20	2:20	4:47	4:47
GRAND TOTAL	5:45	10:06	12:16	7:42	26:46

ALERT AND DECISION
LOGIC AND TIMES



CRITICAL RESPONSE TIME SUMMARY

The opposite page summarizes "best" and "recommended" times required to accomplish specific tasks for emergencies. The best donning times are taken directly from the previous chart on Contingency Egress Best Timelines. The recommended values includes a safety factor multiplier of two on all donning times (rounded to next higher minute). The resulting times are consistent with Apollo simulations for lunar surface EVA's and experienced values for transearth EVA's. (No data are available for experienced values on lunar surface EVA's.)

The Alert and Decision "recommended time" is actually the evaluative path illustrated on the "Alert and Decision" logic chart and applies only to appropriate emergencies. The depress and repress "best" times correspond to the physiological limit (6 psi/min) for a total pressure change of 14.7 psi. The "recommended" times are actually "nominal" times, and are included for reference. The airlock rate is for the nominal physiological limit of 2.5 psi/min. The cabin and sortie module nominal rate is for depressurizing a 2000 ft^2 volume through the airlock vent valve.

Egress to airlock includes 2 minutes for alert and decision (the appropriate value here), 30 seconds to egress to the airlock, 15 seconds to open the hatch, 1 minute for all the crew to enter the airlock, and 15 seconds to close the hatch.

The contingency transfer time is the time required for two men to conduct a contingency EVA transfer from a failed shuttle to a rescue shuttle, and includes the time for transfer by a manipulator arm and the time required to repressurize the airlock in the rescue shuttle. The same time is required for EVA transfer of two men from a sortie module into the cabin through a side hatch.

EVA emergency return is the time required to return to the airlock, close the hatch, and repressurize. The best time is for a translation velocity of 2.5 ft/sec and the recommended is for 0.5 ft/sec. EVA rescue from stand-by is the time necessary for a crewman in an unpressurized suit, with EVLSS checked out but helmet and gloves off, to return a disabled crewman conducting a one-man EVA to a safe environment. The time includes 10 minutes for the rescue crewman to become aware of the problem. He then completes donning at either best or recommended rate. The times to reach the disabled crewman for best and recommended rates are also presented.

CRITICAL RESPONSE TIME SUMMARY

ACTION	TIME (MIN:SEC) BEST TIME	RECOMMENDED
ALERT AND DECISION	2:00	4:00
EMERGENCY SUIT CHECKOUT & PRESSURIZE	2:20	2:20
DON BREATHING MASK	0:30	1:00
DON FIRE PROTECTIVE GARMENT	0:30	1:00
DON IV SUIT (STANDBY)	1:25	3:00
DON IV SUIT	5:46 (7:56)*	12:00 (16:00)*
DON IV SUIT WITH LCG	6:46 (8:56)*	14:00 (18:00)*
DON EVA SUIT, EVLSS, AND EOP	19:59	40:00
DEPRESS AND REPRESS TIMES-CABIN & SORTIE MOD.	2:30	60:00***
-AIRLOCK	2:30	6:00***
EGRESS TO AIRLOCK	-	4:00
CONTINGENCY TRANSFER	-	20:00
EVA EMERGENCY RETURN	10:00	24:00
EVA RESCUE (FROM STANDBY)**-REACH CREWMAN	20:00	21:00
-COMPLETE	37:00	38:00

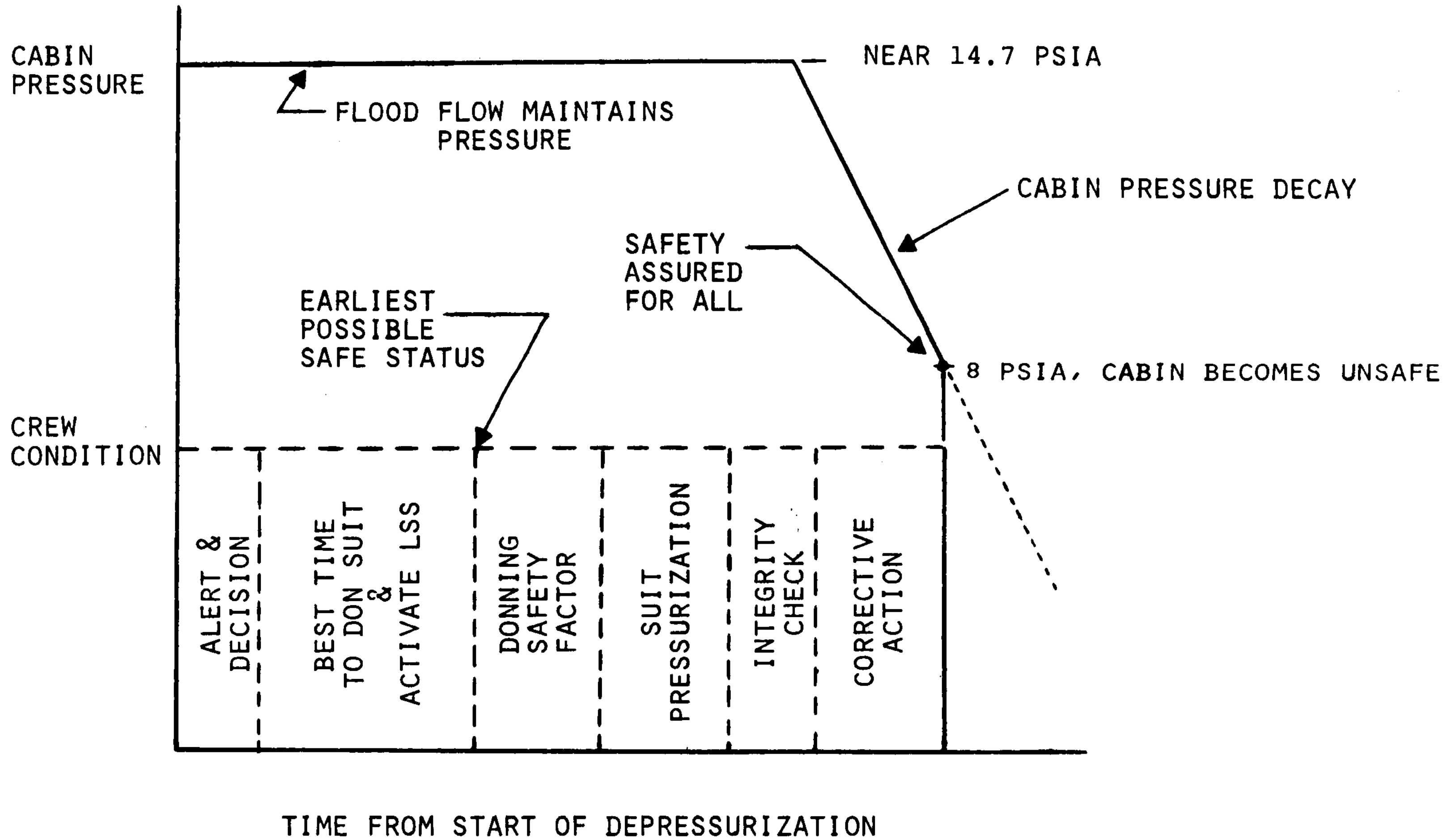
* (LONG TERM)
** INCLUDES 10 MINUTE RECOGNITION TIME
*** NOMINAL TIMES

DEPRESSURIZATION EMERGENCY SAFING CONSIDERATIONS

The opposite chart illustrates the time critical factors in assuring crew safety following a decompression emergency,where it is assumed the emergency scenario taken is to immediately don pressure suits. The upper curve indicates that the orbiter flood flow system, if capable of a high enough flowrate, will maintain cabin pressure near 14.7 psia until the emergency tankage is exhausted. Once the flood flow oxygen/nitrogen is expended the cabin pressure will decay; after the pressure falls below approximately 8 psia the crew will be in danger of experiencing the bends, and the cabin will become unsafe. For example, at the PRR baseline flood flow capability of 150 pph for one hour (3/8" effective hole diameter), the total safe time is about 1 hour and 45 minutes.

The dotted-in lower boxes indicate the sequence of action taken by the crewmen. First, they must be alerted by a warning tone, determine what the nature of the emergency is, and reach a decision to don suits. Next, they must don their suits and activate the suit emergency life support system. At this point, a crewman who can follow the "best" suit donning timeline and who neither makes mistakes nor has any malfunction is safe - his LSS is hooked-up and operating and he would be ok if the cabin pressure had fallen to 8 psia. To allow for less proficient crewmen,a donning safety factor must be added, however. At the end of this delta-time increment everyone will have his suit on and LSS activated. Gross mistakes and/or equipment malfunctions will be immediately apparent and corrective action will be taken; thus a time allotment should be reserved for this function. Less gross problems will be revealed by the suit pressurization/integrity check and corrective action taken at that time. While subsequent checks and corrective actions could possibly be required, these fall in the category of double failures. One allocation for each box shown should assure safety for essentially all cases, and is recommended. The sum of the time allotments given to the boxes, then, is the time for which a safe cabin (or refuge) pressure level must be assured for credible leak rates.

DEPRESSURIZATION EMERGENCY SAFING CONSIDERATIONS



DECOMPRESSION RATE CONSIDERATIONS

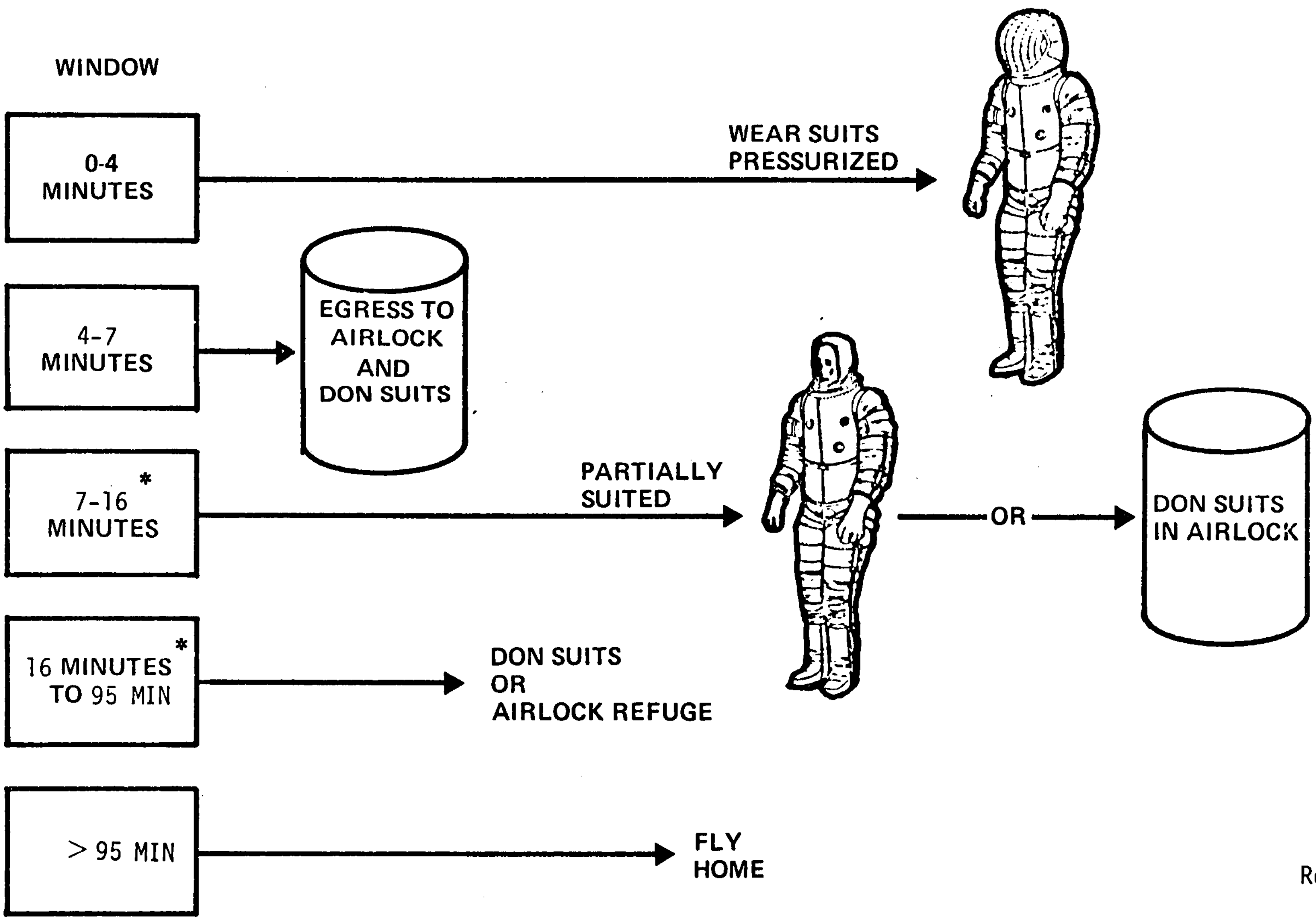
Based on the recommended values of the critical response times, the various options open for survival of decompressions were established and are illustrated on the opposing chart. While a highly capable crewman can better the recommended times, and thus other "last ditch" options are open to him, the shuttle emergency IV concept should not be designed to require these more proficient crew performances. Indeed, in a contingency situation the crewman should be careful, deliberate, and perform all necessary safety checks.

The IV equipment requirements for these options were evaluated in order to arrive at the recommended emergency concept/procedures. It should be noted that the rapid decompression rates indicated are credible in this study, but are not considered in the PRR baseline. Additional study is currently underway at Rockwell relative to the decompression problem

The 95-minute fly-home breakpoint corresponds to the "Panic Mode" return mode, where landing includes worldwide airfields.

Rev.

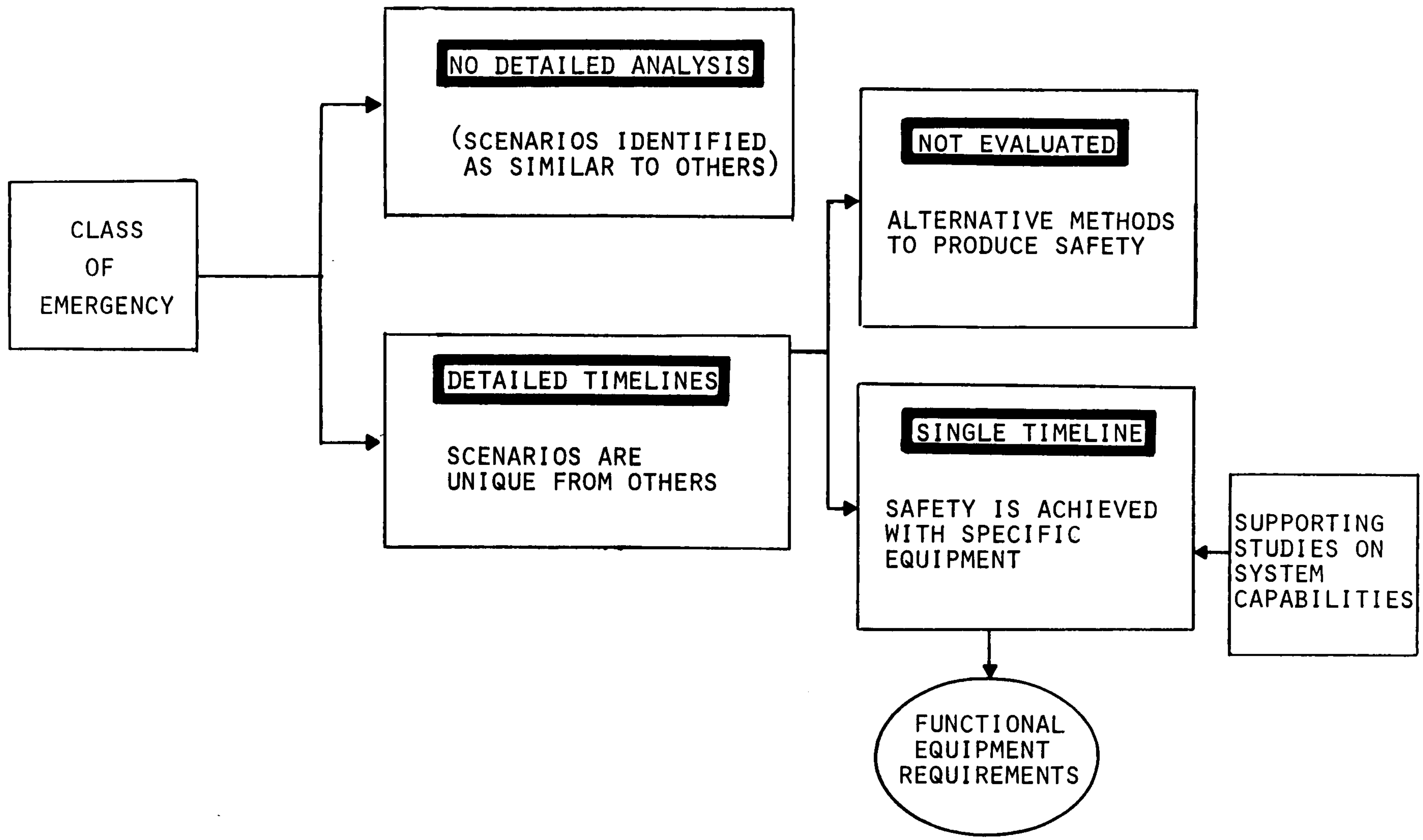
DECOMPRESSION RATE CONSIDERATIONS



Rev.

*16 MINUTES FOR SHORT DURATION SUIT CONFIGURATION, 20 MINUTES FOR LONG DURATION CONFIGURATION

APPROACH FOR TIME CRITICAL EMERGENCY ANALYSIS



SCENARIO ANALYSIS

The eight classes of emergencies were sub-divided into 28 representative scenarios. A timeline was prepared on each to identify equipment requirements and time critical operations. Appendix A presents the equipment requirements by scenario. Appendix B presents a functional description of each item identified.

The first charts in this section present 8 representative scenario functional flow diagrams for determining equipment requirements. Next the major differences due to shuttle design options and vehicle impacts were identified. Finally, a set of equipment common for all options is presented.

SCENARIO ANALYSIS

- REPRESENTATIVE SCENARIO FUNCTIONAL FLOW ANALYSES
- CONTINGENCY CATEGORIES AND FUNCTIONAL REQUIREMENTS
- BASELINE COMMON FUNCTIONAL REQUIREMENTS

REPRESENTATIVE SCENARIO I-a

FIRE CONTAMINANTS CABIN

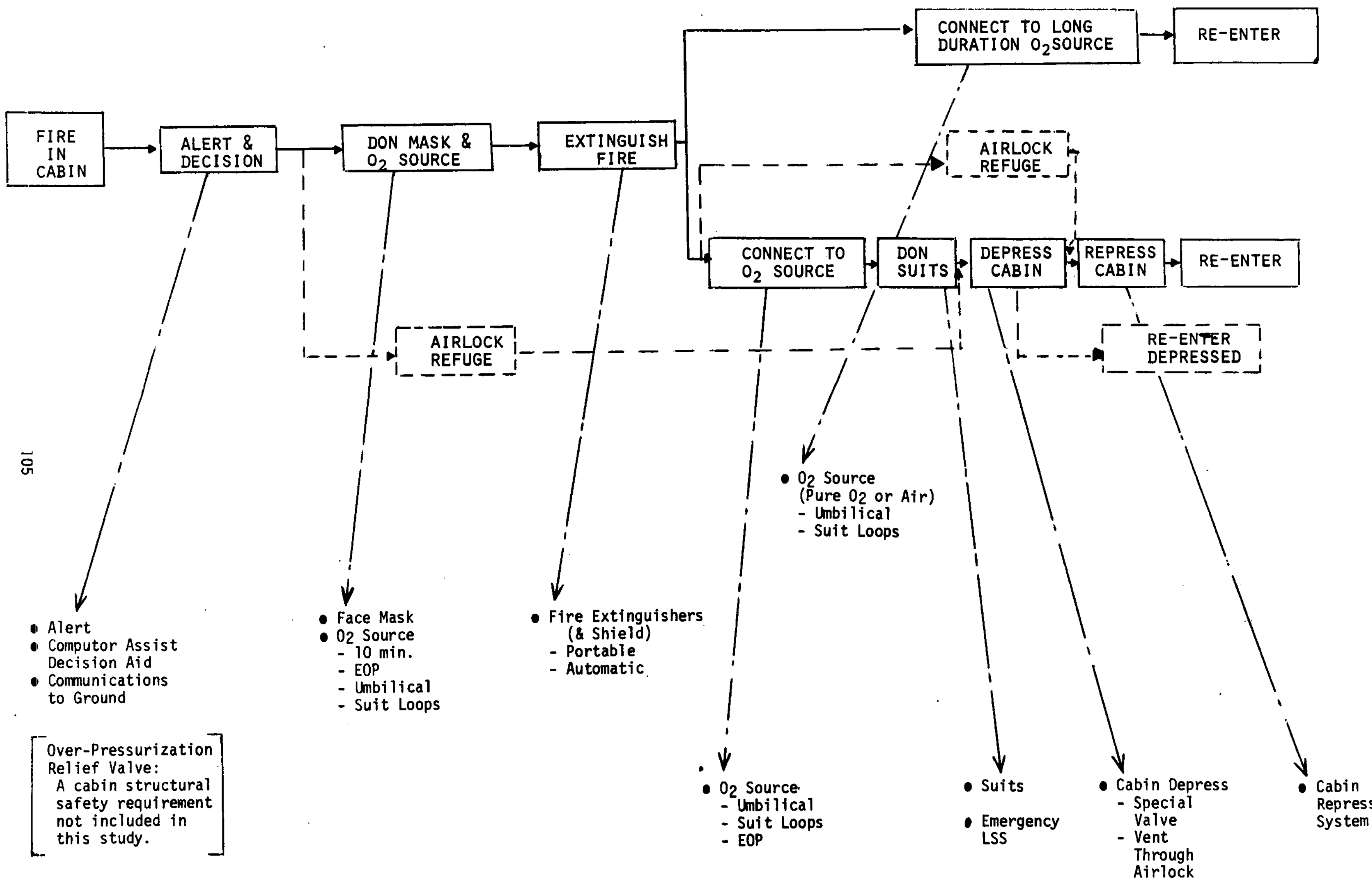
Two alternate paths to safety were considered. The scenario is representative of a general contaminated cabin emergency (e.g., release of toxic substances from an experiment or decomposition of insulations on over-heated electronics, etc.). Cabin purge was not included in the analysis of this scenario because of the very large purge quantities expected to be required to reduce an unknown contaminant and its concentration to an assured acceptable concentration level. (See purge requirements curve under Assessments)

The time required to initiate face mask operation is 3 to 5 minutes, including alert and decision. The contaminant sources are not known and, consequently, the concentration levels are also unknown. However, since the time required is short, essentially all contaminant exposures should be survivable with little or no permanent damage to the crewman.

Long term use of face masks does impose a risk of O_2 toxicity. Data from NASA CR-1205 (III) indicates O_2 toxicity symptoms can occur after 4 hours with pure O_2 at 14.7 psia; the nominal time for occurrence is 10 hours and as high as 15 hours has been observed before symptoms appear. Based on the same data, the Apollo astronauts were exposed to pure O_2 in excess of the nominal time. Obviously the data are conservative. For an emergency 10 hours of exposure to 14.7 psia, O_2 should be acceptable.

Rev.

REPRESENTATIVE SCENARIO I-A
FIRE CONTAMINATES CABIN



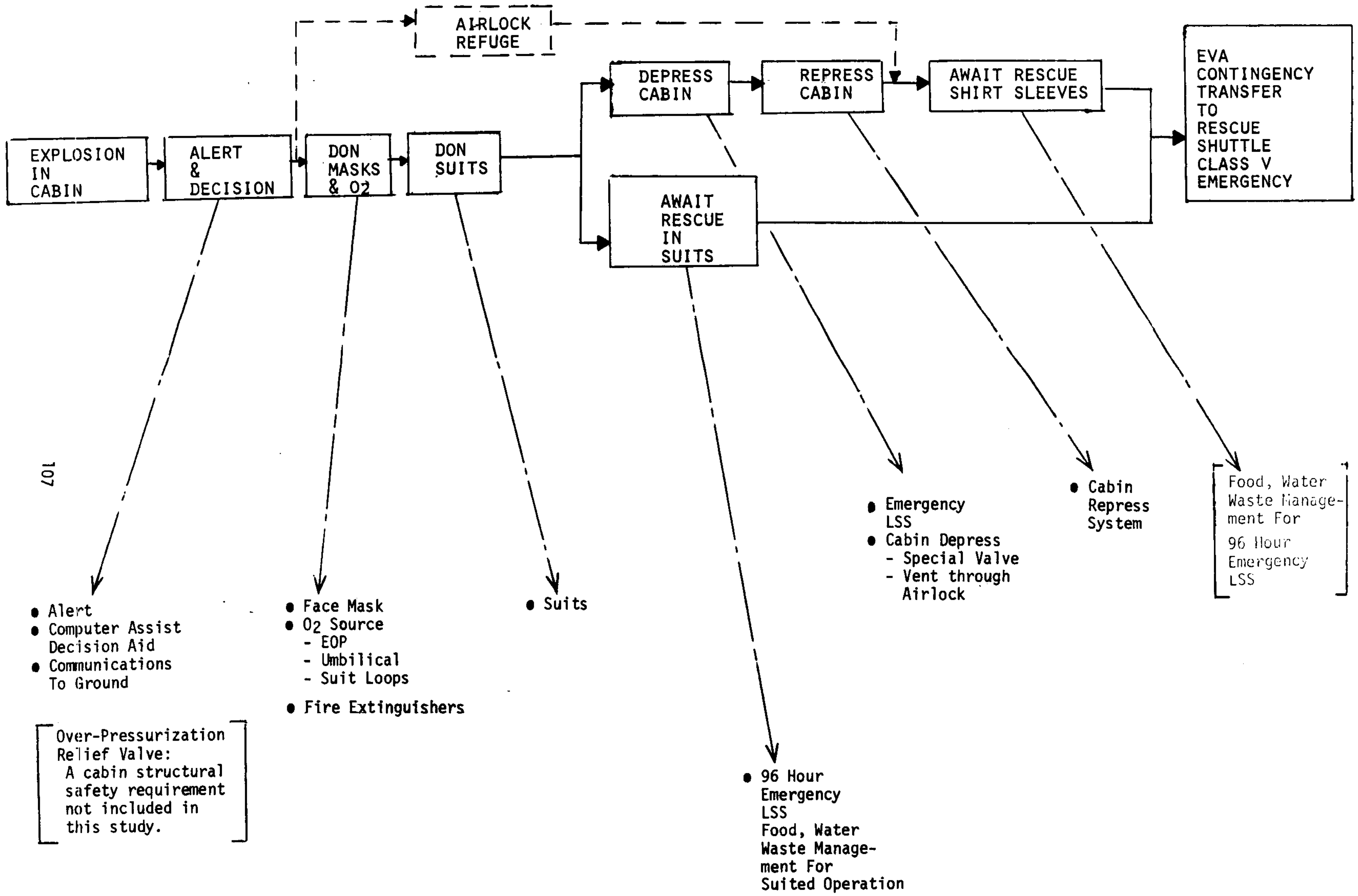
REPRESENTATIVE SCENARIO II-a

Two alternative paths to safety were considered. The primary difference between these is the duration of the emergency life support system. For the 96 hour duration a two gas system (O_2 and N_2) is required to prevent O_2 toxicity problems with operation in a cabin at 14.7 psia.

The EOP and EVLSS both store O_2 and 2 each are required on all flights. By simply activating the O_2 supply, this O_2 can be made available for other uses. Either cabin pressurization or O_2 make up for metabolic consumption. For the option to depress and repressurize the cabin to vent contaminants, the EVA system O_2 can be used as a supplemental source. When only 2 men are on the shuttle, the EOP and baseline flood flow O_2 is sufficient for the 96 hour wait and cabin repress. (By allowing the cabin O_2 partial pressure to fall slightly, but not below 2.2 psi). If each additional man is assigned an EOP, no additional carry-on O_2 tankage would be required, even with up to 10 men.

Rev.

REPRESENTATIVE SCENARIO II-A
EXPLOSION IN CABIN, SHUTTLE CANNOT RE-ENTER
(PRESSURE IS MAINTAINED)



REPRESENTATIVE SCENARIO III-b

UNREPAIRABLE LEAK IN CABIN

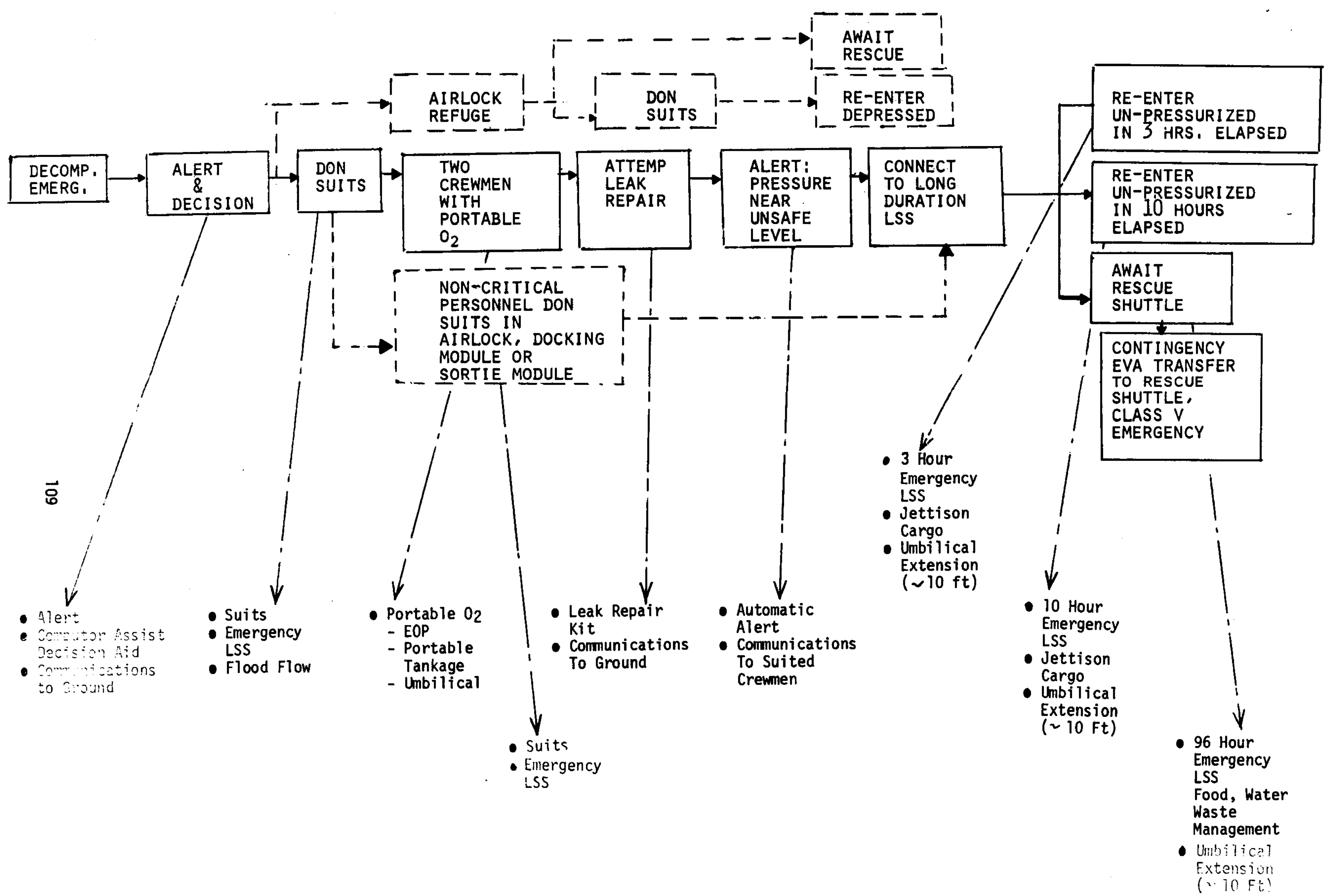
A number of conditions and options are possible for a cabin decompression. The opposite chart presents a scenario where there is a limited time available for repair activities; but due to the location and size of the hole there is inadequate time to complete repairs. The worst case decompression rate and available options are discussed elsewhere.

The airlock as a refuge is an optional item for either long term or temporary use. In addition, it might be employed as a convenience area for food, water, and waste management during on-orbit stay for 96 hours. In that case the crew would alternate on approximately 12 hours shifts, depressurizing the airlock each time. However, the quantity of expendable gas is large (approximately 65 lbs of gas, 130 lb penalty, for 8 airlock operations at 8.0 psia). In addition the crew must interchange gas connectors while depressurized. Consequently that approach is not recommended.

Conducting a repair of a leak once the cabin had been depressurized requires both flood flow and a second emergency gas storage for repressurization. The latter would require 150 lbs of air (for 14.7 psia), 300 lbs penalty. Since the leakage may be located behind a permanently installed part, repair can not be assured. Therefore the capability of repressurization of the cabin after a repair of a leak is not recommended (high penalties, no assurance of success).

Rev.

REPRESENTATIVE SCENARIO III-B
UNREPAIRABLE LEAK IN CABIN



REPRESENTATIVE SCENARIO IV-a

BLOCKED ACCESS TO CABIN, NO DOCKING MODULE

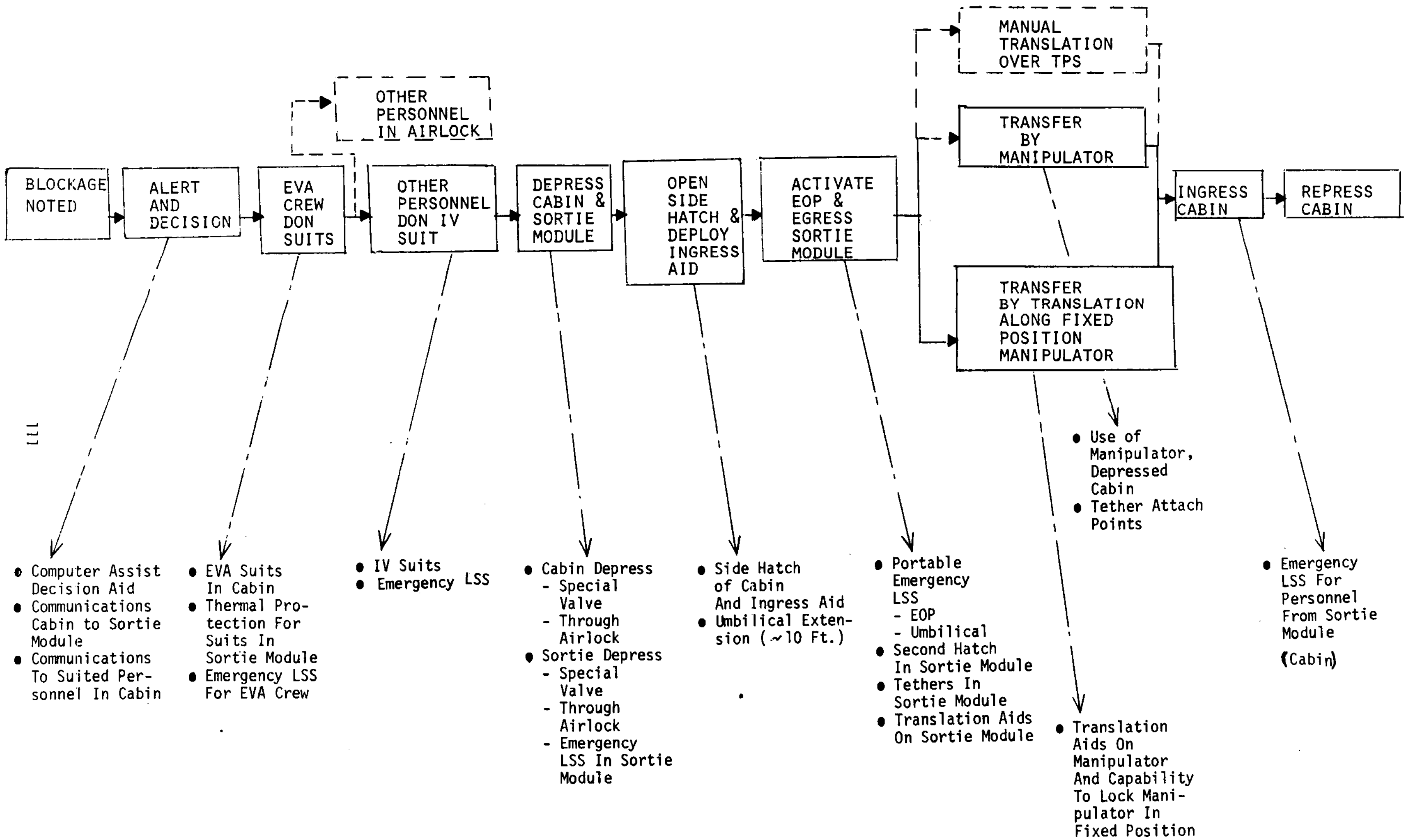
The problem of blocked access is the failure of one hatch to open, or some other blockage in the sortie module egress path. The current baseline is that personnel can not re-enter in the sortie module; they must return to the cabin. Another alternative is to bring up a rescue shuttle. However, functionally, the only difference is that the men perform an EVA transfer to the rescue shuttle in lieu of the cabin.

The manipulator is an attractive option for crew translation to the side hatch. The men never touch the TPS, eliminating possible damage and are provided a continuous path to the ingress hatch. As currently baselined, the manipulator can reach the side hatch. However, the manipulator design must be impacted to allow either active use while the cabin is depressurized or locking in a fixed position. The maximum duration required of the portable emergency life support system was 24 minutes during the transfer with a fixed position manipulator.

Rev.

REPRESENTATIVE SCENENARIO IV - A

BLOCKED ACCESS TO CABIN, NO DOCKING MODULE



REPRESENTATIVE SCENARIO V-a

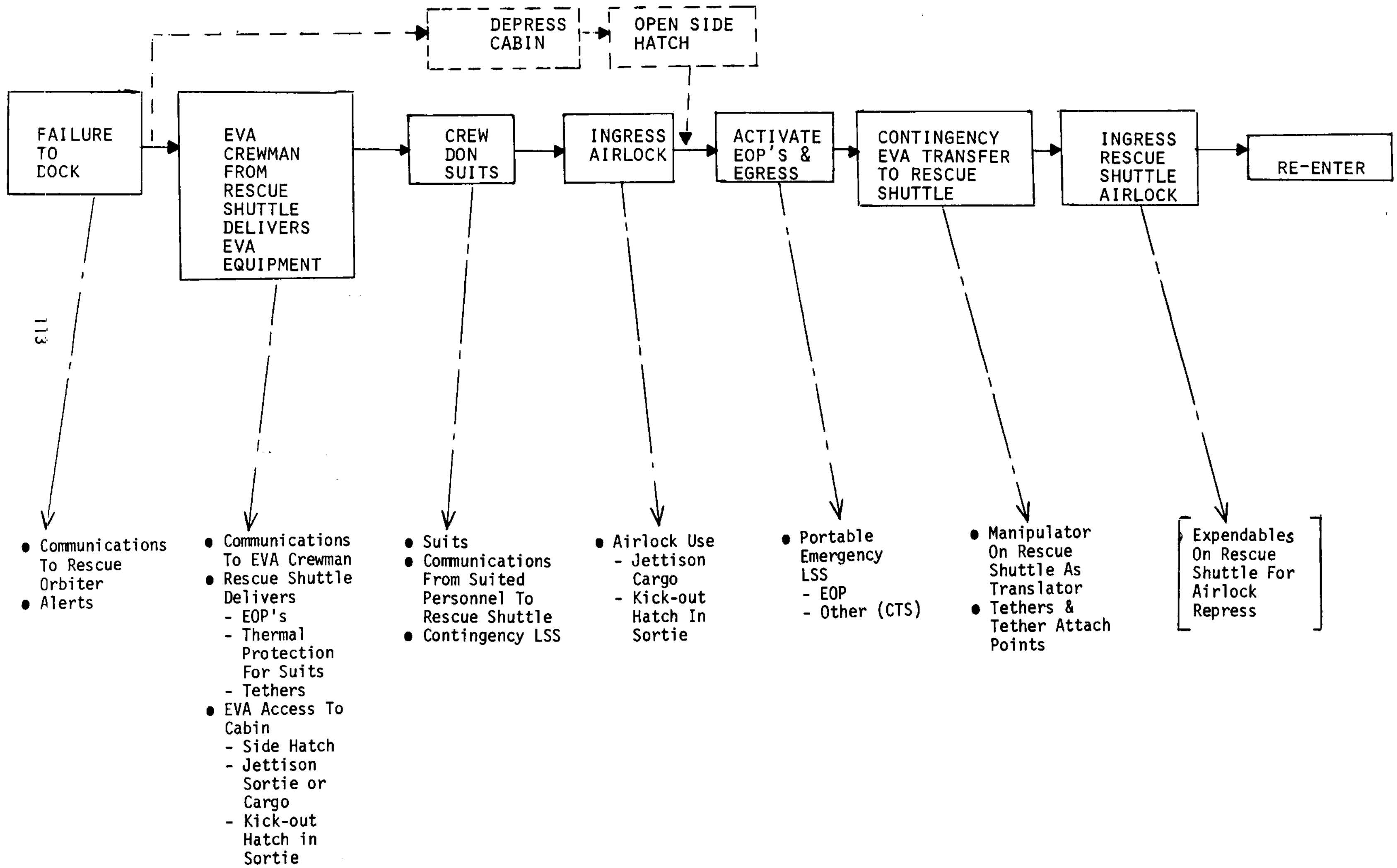
FAILURE OF RESCUE SHUTTLE TO DOCK

A failure of the rescue shuttle to dock may be due to several circumstances.

- o Explosion in cabin causes failure of vehicle stabilization system - (Class II Emergency)
- o Explosion in cargo bay affects docking module and prevents attachment of a second docking module - (Class II Emergency)
- o Decompressed cabin deactivates vehicle stabilization system
- o Shuttle was launched without docking module and design does not permit installation of docking module on-orbit (Any emergency which prevents shuttle re-entry)

EVA from the rescue shuttle can be employed to transfer equipment necessary for personnel to transfer EVA to the rescue shuttle. The transfer time, assuming rescue shuttle manipulator assistance, required 20 minutes on a portable emergency LSS.

REPRESENTATIVE SCENARIO V -A
FAILURE OF RESCUE SHUTTLE TO DOCK



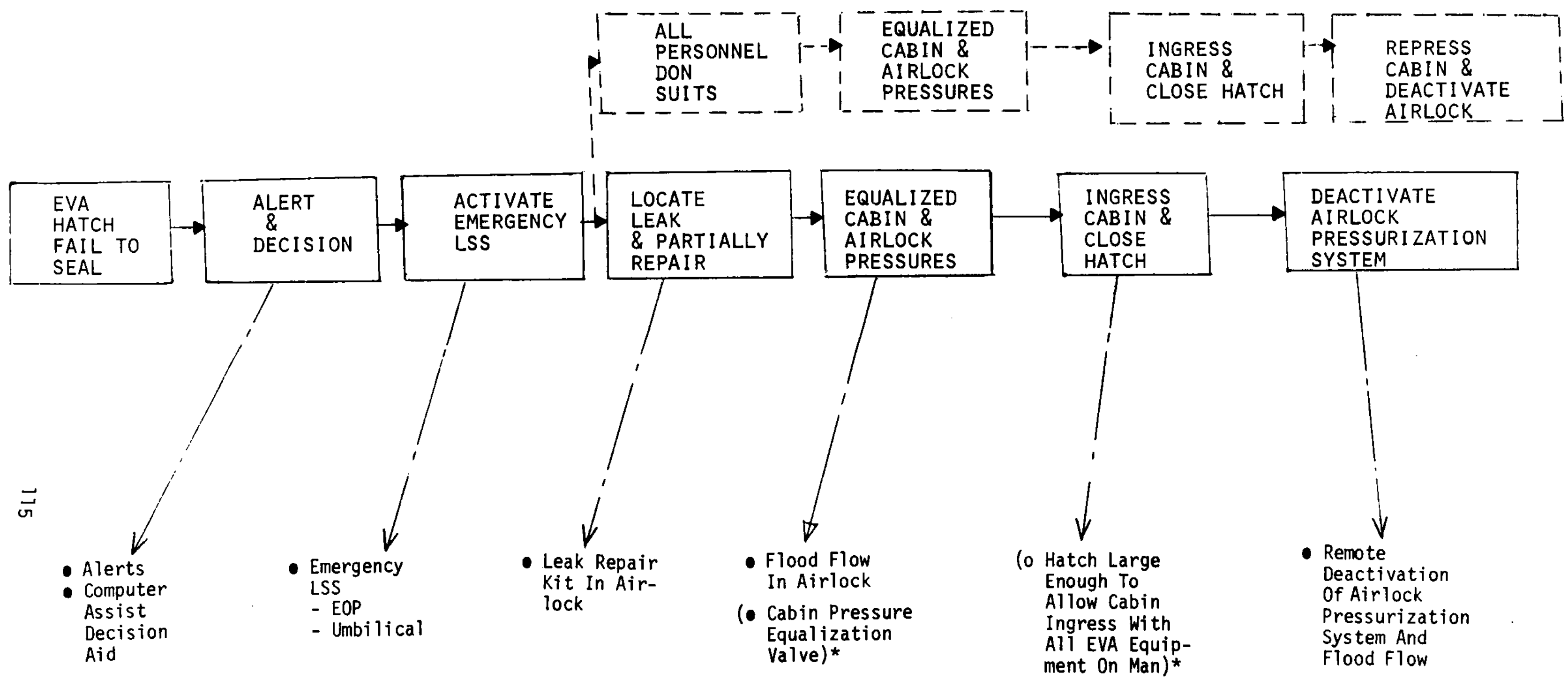
REPRESENTATIVE SCENARIO VI-a
EVA HATCH FAIL TO SEAL

The EVA hatch may be damaged by the egress and ingress activities of the EVA crewman. The seals may be cut or torn by accidental impact with EVA equipment, and the hatch may not close completely due to tethers remaining in the hatch when closed. A leak of limited magnitude but in excess of the flood flow rate can result. Partial repair reduces the rate so that the EVA crewman can equalize cabin and airlock pressures and ingress the cabin.

Failure of the EVA hatch to close must be designed to acceptable risk. If not, all personnel in the cabin must don suits to allow the crew to ingress the cabin.

Rev.

REPRESENTATIVE SCENARIO VI - A
EVA HATCH FAIL TO SEAL



* Required for Normal EVA

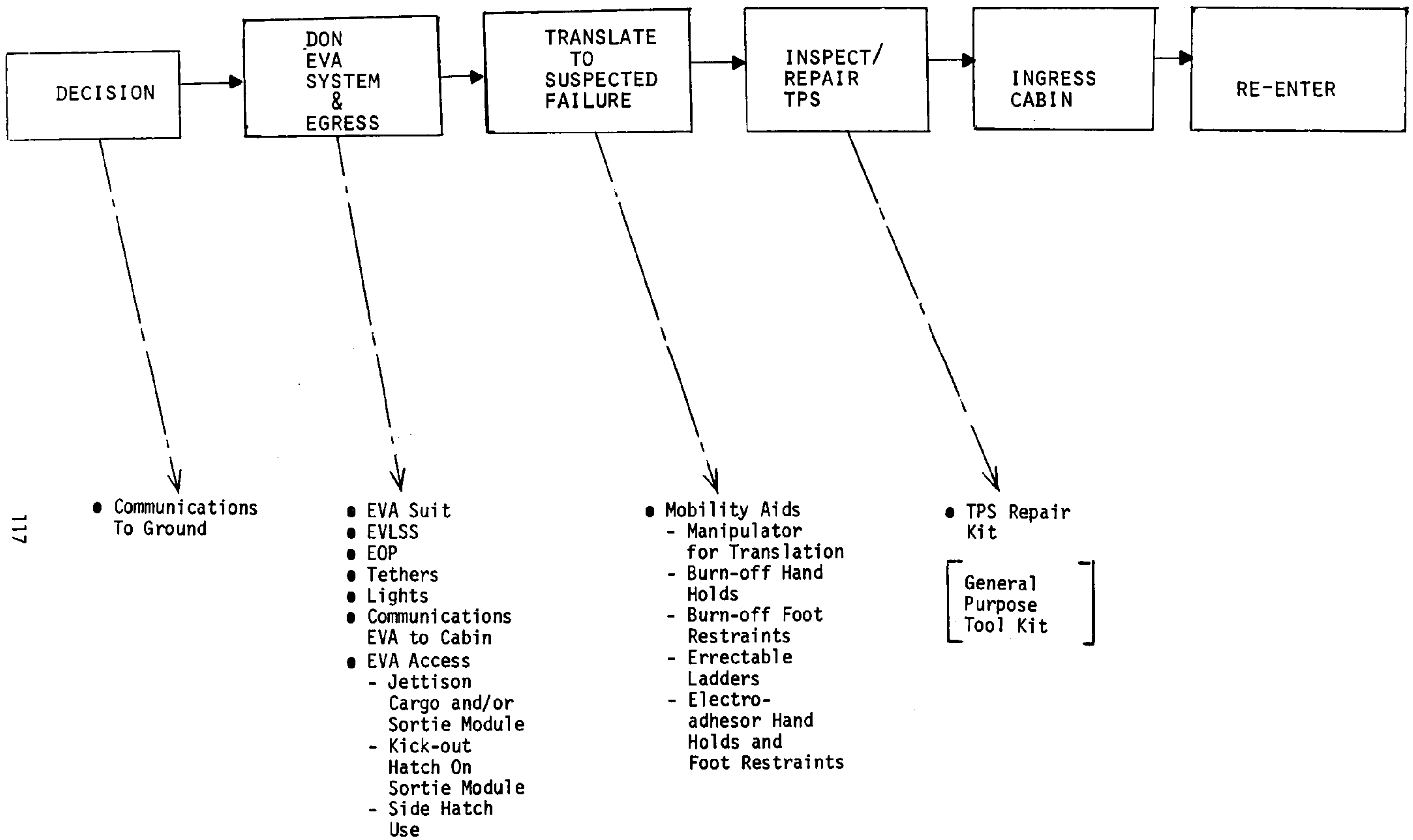
REPRESENTATIVE SCENARIO VII-a

The opposite chart presents an example of a large number of potential emergencies requiring EVA. Other examples are presented below.

CAUSE	LOCATION
Booster or Abort SRM Motor Case Burn-Through	Reentry TPS damage on orbiter belly Structural damage on orbiter belly Aerodynamic control surface damage
Collision with Booster, Abort SRM, or Drop Tanks During Separation	Upper rear fuselage Lower fuselage
Collision During Docking or Cargo Manipulation	Docking tunnel region Cargo bay Cargo bay doors
Collision with Meteoroid or Orbiting Debris	Anywhere on shuttle exterior
Cargo Shift During Ascent Boost or Orbital Maneuvering	Cargo bay
Windshield Obstructed by Contaminants	Windshield area
Explosion in Payload	Cargo bay

Rev.

REPRESENTATIVE SCENARIO VII - A
TPS INSPECTION/REPAIR



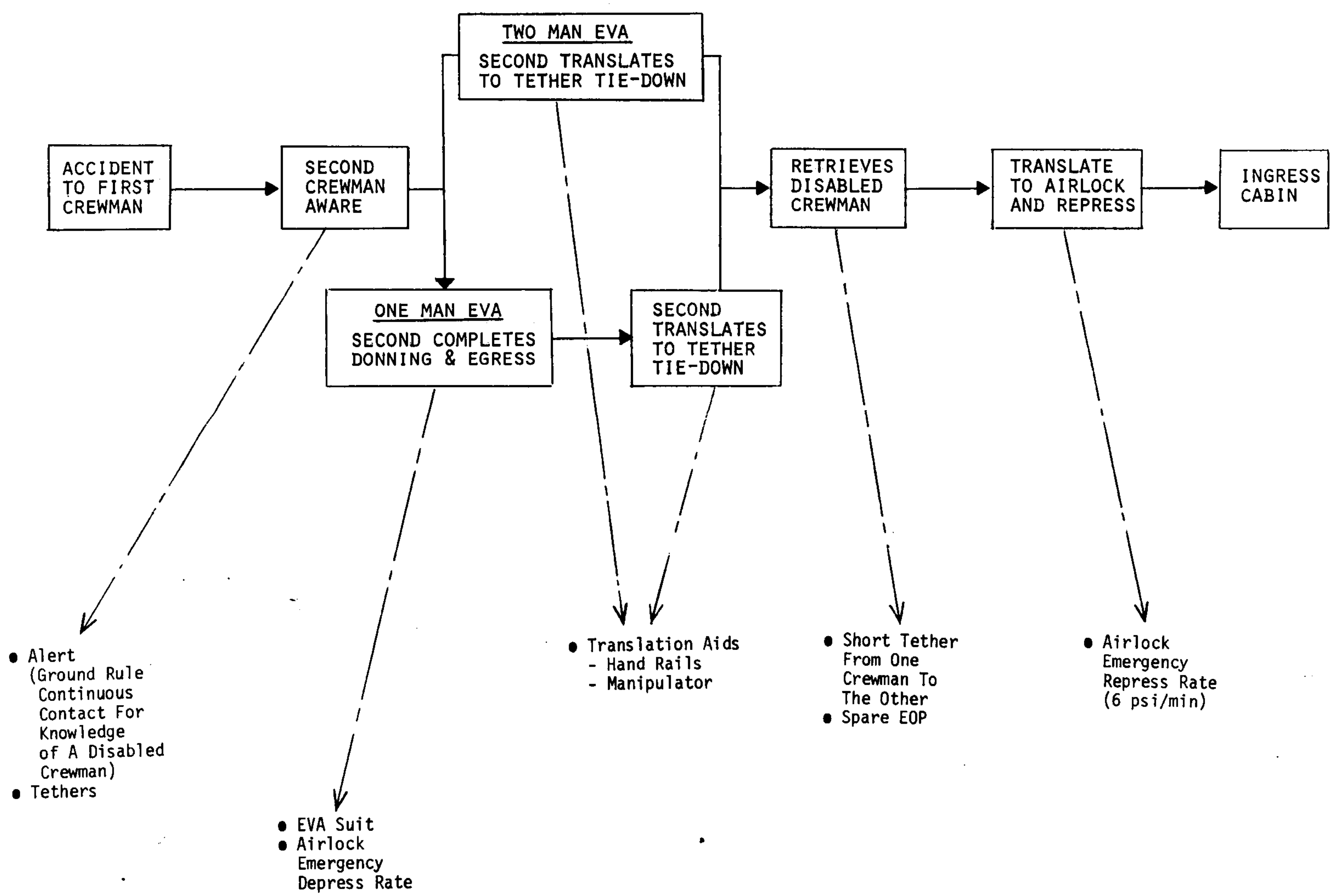
REPRESENTATIVE SCENARIO VIII-a
DISABLED DRIFTED EVA CREWMAN

An EVA crewman may become disabled by either sickness or accident. A second crewman is required to assist the first. Both two men EVA's and one man EVA's (with second man on stand-by) were considered. Both two and one man EVA's were found to be safe.

For two man EVA's, the disabled crewman must have approximately 16 minutes of life support available before a second man can render aid (assuming 10 minutes elapses before his buddy is aware of problem).

For one man EVA's 23 minutes of LSS is required for the disabled crewman (again 10 minutes to become aware). For the rescue crewman 30 minutes total life support is required. In the latter case, the rescue crewman is in the cabin suited, but helmet and gloves off, life support systems donned and checked-out but not activated.

REPRESENTATIVE SCENARIO VIII-A
DISABLED, DRIFTED EVA CREWMAN



CONTINGENCY CATEGORIES AND FUNCTIONAL REQUIREMENTS

The major contingency categories which were found to distinguish and drive emergency requirements are illustrated on the opposing page. It is seen that a set of baseline functional requirements common to all major categories emerge. The chart also shows that the lack of an ability to re-enter unpressurized, blocked access to a manned (sortie) module, or unavailability of a rescue vehicle or capability to dock with it become major impact items.

CONTINGENCY CATEGORIES AND FUNCTIONAL REQUIREMENTS

- ORBITER CANNOT RE-ENTER UNPRESSURIZED
- IV ACCESS TO SORTIE MODULE
- RESCUE VEHICLE CANNOT DOCK

⇨ ⇨

- BASELINE COMMON REQUIREMENTS
- LONG TERM LSS FOR IV SUITS
- CONTINGENCY EVA TRANSFER SYSTEM

CHANGE:

- ORBITER CAN RE-ENTER UNPRESSURIZED

⇨

- SHORT TERM LSS FOR IV SUITS

ADD:

- BLOCKED IV ACCESS TO SORTIE MODULE

⇨

- CONTINGENCY EVA TRANSFER SYSTEM FROM SORTIE MODULE

ADD:

- NO RESCUE VEHICLE (DEVELOPMENT FLIGHTS)

⇨

- ESCAPE/RE-ENTRY CAPSULE

BASELINE COMMON FUNCTIONAL REQUIREMENTS

Functional and location requirements for equipment found to be common to all the major contingency categories are indicated and form a baseline requirements set.

BASELINE
COMMON FUNCTIONAL REQUIREMENTS

ITEM	LOCATION			
	CABIN	EXTERIOR	AIRLOCK	SORTIE MODULE
· IV SUITS	√			
· EVA SUITS AND PORTABLE LSS			√	
· GAS MASKS & OXYGEN	√			√
· FIRE EXTINGUISHERS	√			√
· ALERTS	√		√	√
· COMPUTER DIAGNOSIS	√			
· FLOOD FLOW	√		√	√
· LEAK REPAIR KITS	√		√	√
· EXTERIOR REPAIR KIT & TOOLS			√	
· MOBILITY AND LIGHTING AIDS		√		
· GROUND COMMUNICATIONS	√			
· HARDLINE COMMUNICATIONS (TO SUITS OR HEADSETS)	√		√	√
· EVA RF COMMUNICATIONS		√		
· PAYLOAD JETTISON		√		

IMPACTS EVALUATION

- CONTINGENCY IV LSS
- CONTINGENCY IV LSS CONCEPTS
- COMPARISON OF CONTINGENCY IV LSS CONCEPTS
- INTEGRAL SUIT LOOP DESCRIPTION
- RECOMMENDED CONTINGENCY LSS
- EOP PACKAGING EVALUATION
- EMERGENCY LIFE SUPPORT COMMONALITY LOGIC
- AIRLOCK AS REFUGE
- AIRLOCK EVA RESCUE CONSIDERATIONS
- CONTINGENCY EVA ACCESS OPTIONS
- FLOOD FLOW HOLD OPTIONS
- CONTAMINATED CABIN OPTIONS
- SORTIE LAB CONTAMINATION OPTIONS
- CONTAMINATED CABIN COMMONALITY LOGIC
- RESCUE ORBITER CONTINGENCY TRANSFER
- CONTINGENCY TRANSFER FROM SORTIE MODULE
- BLOCKED ACCESS IN AIRLOCK
- DEVELOPMENT FLIGHTS

CONTINGENCY IV LSS

A significant amount of effort was devoted to trades to select and identify requirements for the emergency IV life support system. The opposing page illustrates the preliminary screening process and concepts considered in selecting the basic approach of a closed loop system. Following charts present detailed trade results on the closed loop system alternates.

CONTINGENCY IV LSS

CONTINGENCIES
- DEPRESSURIZED CABIN
- CABIN GAS CONTAMINATED (SHUTTLE CANNOT RE-ENTER, PRESSURE IS MAINTAINED)

→

CONCEPTS
- OPEN LOOP
- SEMI-OPEN LOOP
- SEMI-CLOSED LOOP
- CLOSED LOOP

→

SELECTION

CLOSED LOOP (MINIMUM WEIGHT AND VOLUME)

CONTINGENCY IV LSS CONCEPTS

Four systems were analyzed as candidates for the closed loop contingency IV LSS, ranging from an almost completely carry-on system to a completely integral system.

The EVLSS is almost completely a carry-on system, and takes advantage of commonality with EVA equipment, two sets of which are already required for other contingency reasons. The vehicle interface is for stowage (perhaps under the seat) and for a cooling water outlet and umbilical. An umbilical water loop is already recommended for the airlock, and the scar penalty to run additional flow and plumbing is small. One major disadvantage is that the IV suits must have liquid cooling garments (LCG's).

The breathing vest concept is derived from the Litton Contingency Transfer System (CTS), and is carry-on except that now both vehicle water loops and oxygen are required. It is semi-closed loop. Disadvantages are extra suit complications for both the breathing vest system and the LCG, as well as lack of any experience with the concept past the prototype stage.

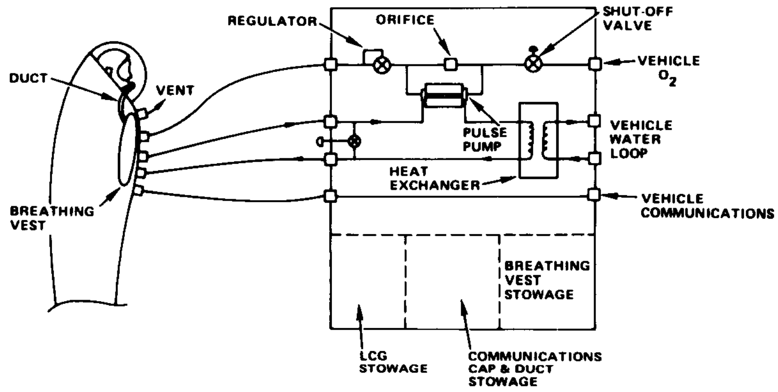
The carry-on closed vent system uses both vehicle water and oxygen, and interfaces for condensate storage and power. It uses a high recirculating vent flow (13 ACFM) for cooling, thus simplifying the suit.

The next logical step is the integral suit loop, requiring greatest vehicle scar, but making most complete use of existing vehicle capabilities and thus minimizing duplication of LSS equipment and expendables. It again cools by a high recirculating vent flow.

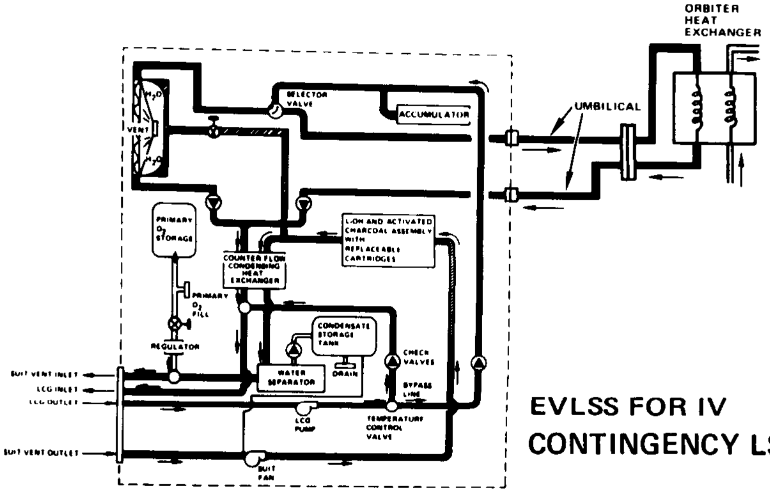
Redundancy provisions were not included in the concepts and trades at this stage, and should be included in future, more detailed studies.

Rev.

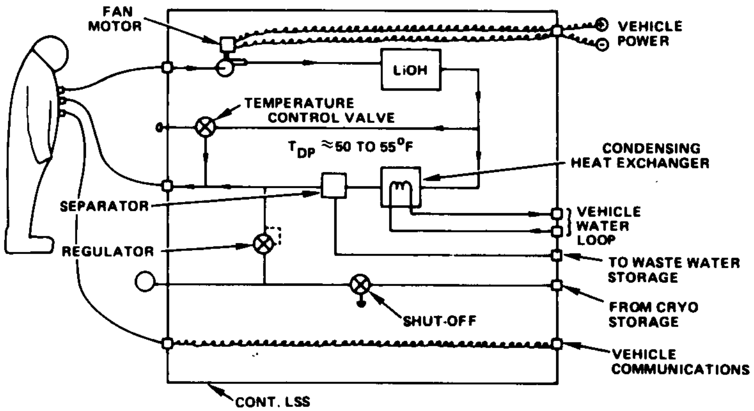
CONTINGENCY IV LSS CONCEPT



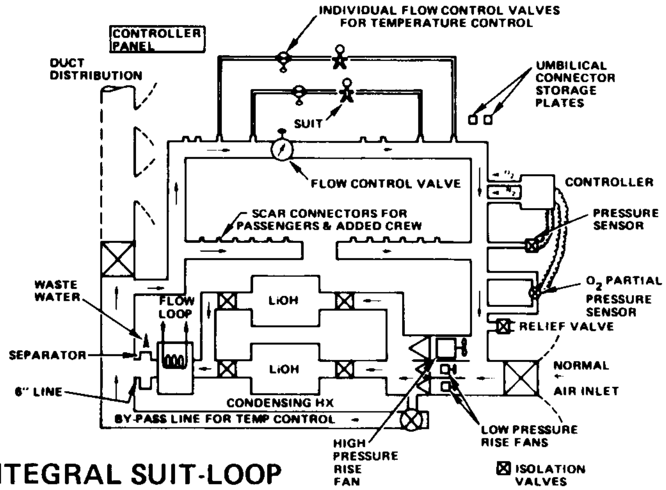
BREATHING VEST SYSTEM SCHEMATIC



EVLSS FOR IV
CONTINGENCY LSS



CARRY ON UNDER THE SEAT
CLOSED VENT SYSTEM



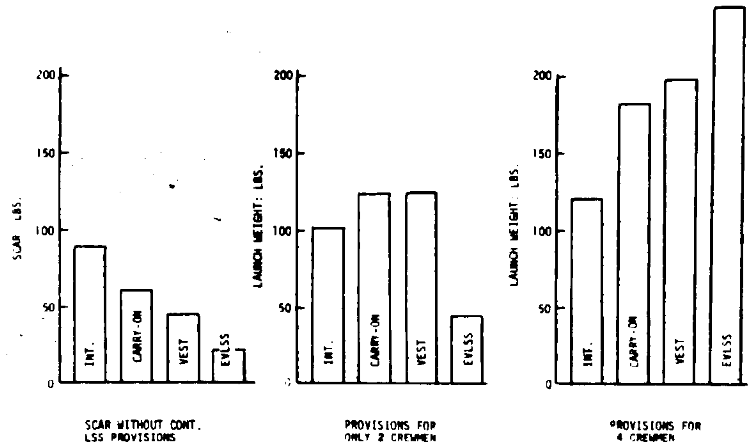
INTEGRAL SUIT-LOOP

COMPARISON OF CONTINGENCY IV LSS CONCEPTS

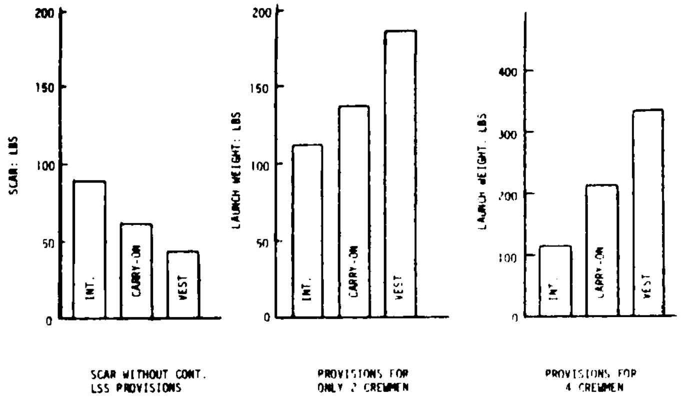
The opposing chart shows scar and launch weight penalties for the LSS concepts described on the previous chart. For the case of a 3-hour contingency LSS it is seen that the carry-on EVLSS provides the minimum scar, and also results in the least launch weight for a 2-man crew (since 2 EVLSS's are already required for other contingency reasons). For a four-man crew, the EVLSS becomes unattractive from a launch weight viewpoint, but still has the lowest scar and might be preferable if it were not for large vehicle airlock impacts required for four men to don EVLSS's while using the airlock as a temporary refuge. Only if adequate flood flow or a sufficiently small credible leak rate can be guaranteed to permit suit donning in the cabin, can the EVLSS remain a viable contender for the 3-hour case.

The integral suit loops are superior for the 10-hour contingency LSS based on launch weight, and are preferred. They are clearly the winner for longer duration, and thus integral suit loops are preferred for all cases.

COMPARISON OF CONTINGENCY IV LSS CONCEPTS



COMPARISON OF 3 HR. CONT. LSS CONCEPTS



COMPARISON OF 10 HR. CONT. LSS CONCEPTS

2-MEN: PREFER EVLSS

OR

4-MEN: PREPER INTEGRAL SUIT LOOPS

96 HR CONT. LSS CONCEPTS

PREFER INTEGRAL SUIT LOOPS

INTEGRAL SUIT LOOP LSS DESCRIPTION

The opposite chart presents the system schematic for integral suit loops. The system is an integral part of the primary life support system for shirtsleeve operations. All expendables for the system are the same as those for the 96 hour on-orbit wait for rescue (shirtsleeves).

ITEM	WEIGHT (LBS)
Valves, Isolation (6)	28.8
Flow Control Valve	5.4
6" Dia. Lines (0.032" Wall)	21.6
High Pressure Rise Fan (Mod From Low Pressure)	5.8
Modifications to Equipment For High Pressure Use	12.0
Oversized Separator	4.5
Modifications to Gas Composition Control System	2.3
Scar For Up to 10 Men	7.7
	88.1 lbs

PROVISIONS PER MAN	
Umbilical	5.6 lbs
Individual Flow Control Valve	2.0 lbs
Connector Stowage	0.4 lbs
TOTAL	8.0 lbs/man

The suit flow requirements are 12 ACFM/man with a dew point of 50°F or less. The peak metabolic load is estimated at 1200 BTU/hr. The average metabolic rates were estimated as the same as Apollo Command Module emergency depressurized cabin rates. The values (per man) from NASA CR-1205(III), page 10-41, are as follows:

METABOLIC RATES FOR PRESSURE SUITED OPERATION

Peak	:	1200 BTU/hr	
On-Duty Average	:	780 BTU/hr(8 hrs)	Daily Avg : 500
Off-Duty	:	400 BTU/hr(8 hrs)	
Sleep	:	320 BTU/hr(8 hrs)	

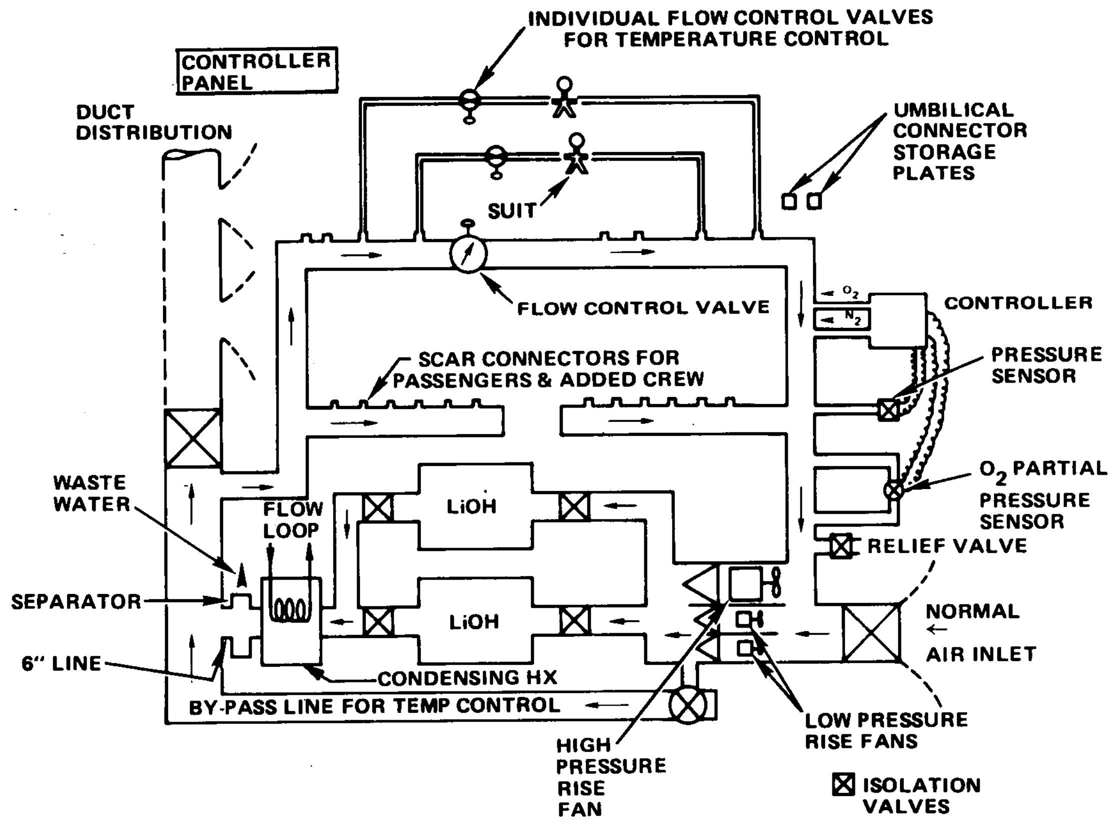
To provide the variations from min. to max. metabolic loads an individual flow control valve is required.

The mixed gas system provides N_2 to prevent O_2 toxicity during a long term suited operation. Alternately, the suit pressure could be reduced below 8.0 psi with pure O_2 after the men have pre-breathed.

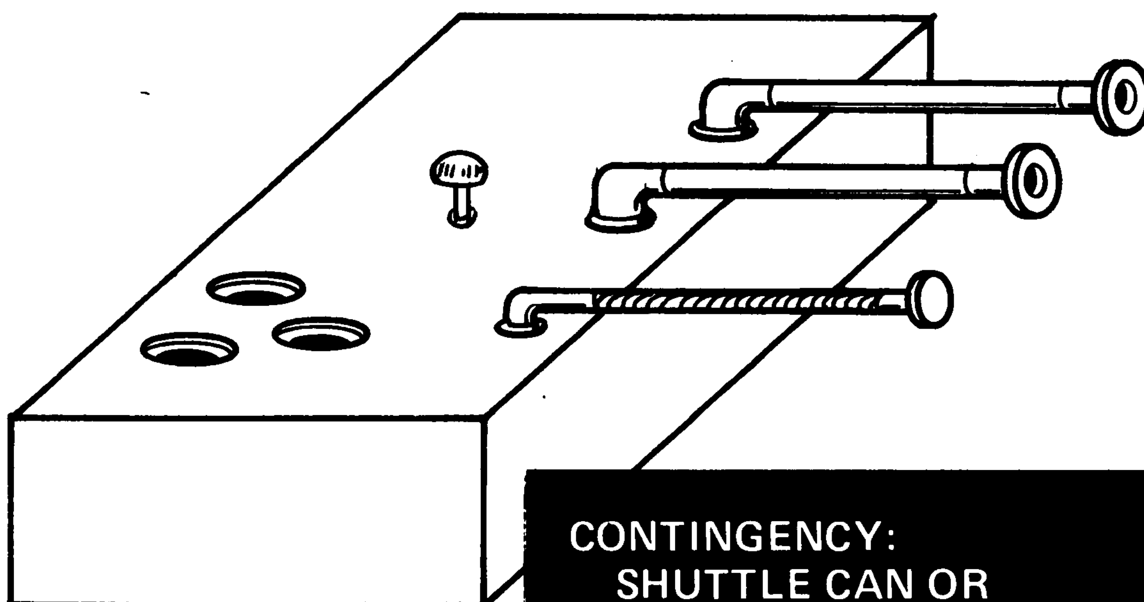
The suit loops are also used as a gas cooling system during suited IV-Standby (helmet and gloves off). The high pressure rise fan is activated, but the isolation valves remain open for normal cabin air circulation. A damper valve may be required in the return duct distribution system. The damper valve would increase the pressure drop available to the suits to provide sufficient flow at 14.7 psia.

Rev.

INTEGRAL SUIT LOOP LSS DESCRIPTION

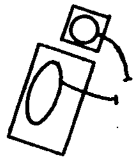
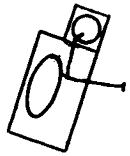
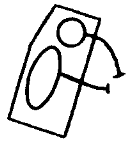
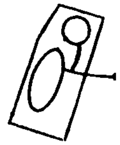


RECOMMENDED CONTINGENCY
LSS



CONTINGENCY:
SHUTTLE CAN OR
CANNOT ENTER DEPRESSURIZED;
3, 10, OR 96 HR CONTINGENCY

EOP PACKAGING EVALUATION

EOP USES	EOP CONFIGURATIONS			
				
EVA SAFETY	BEST	OK	BEST	OK
EVA WEIGHT AND VOLUME	OK	GOOD	BETTER	BEST
CONTG. EVA. X-FER	GOOD	GOOD	POOR	POOR
IVA SERVICING ALT. CONFIG. (NON-EMERGENCY)	GOOD	GOOD	N/A	OK IF AUTOMATIC
PORTABLE FACE MASK O_2 SOURCE	GOOD	GOOD	POOR	POOR
SUPPLEMENTAL CABIN OXYGEN SOURCE	GOOD	GOOD	GOOD	GOOD

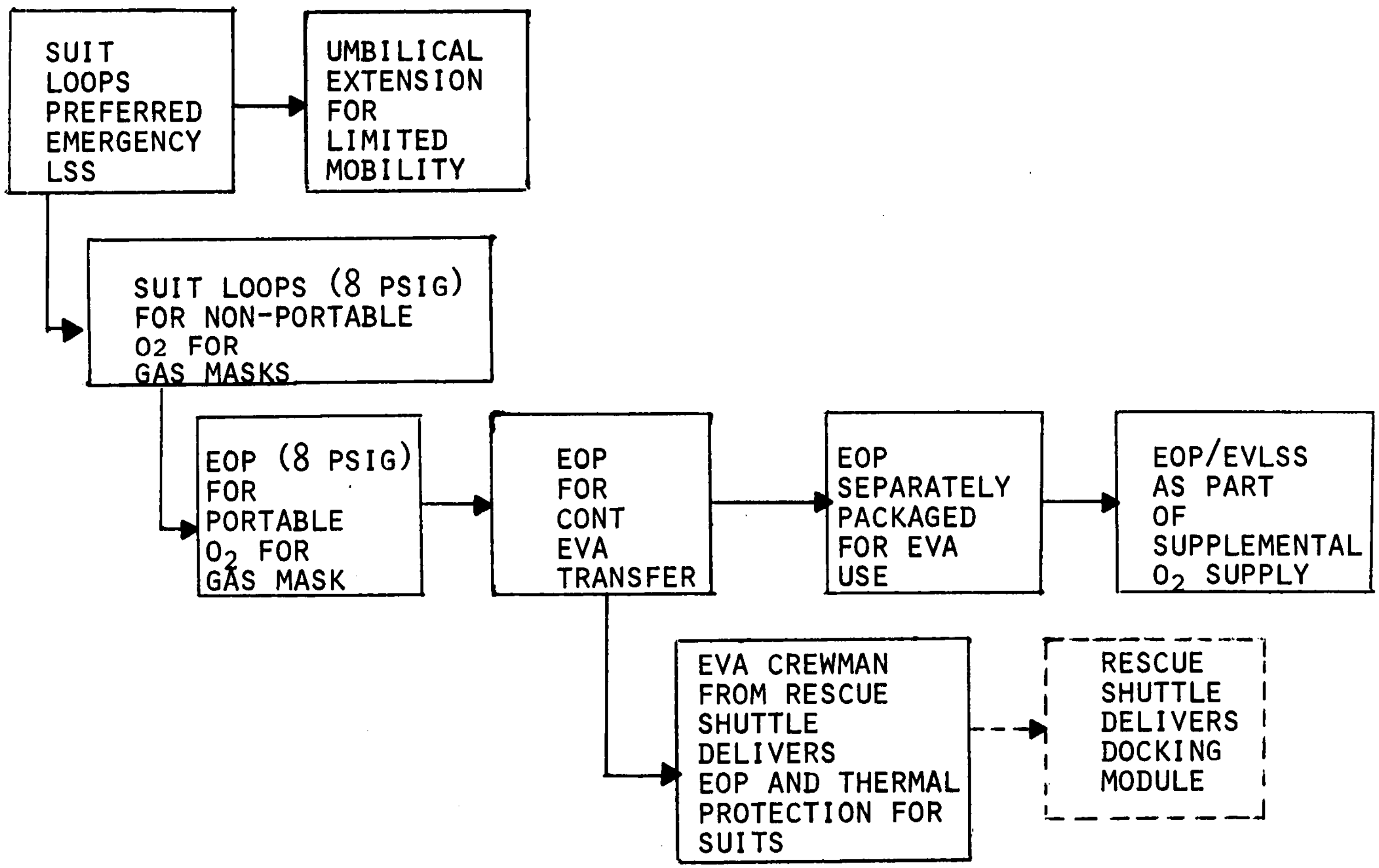
RECOMMEND

- COMMONALITY
- EVA EFFECTIVENESS

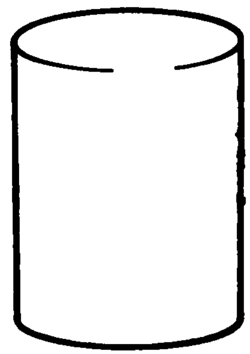
Rev.

EMMERGENCY LIFE SUPPORT

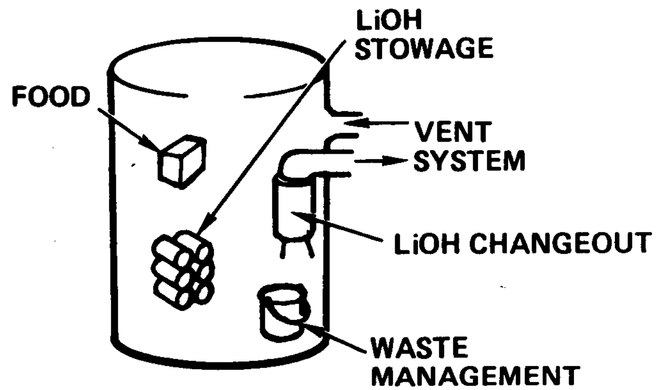
COMMONALITY LOGIC



AIRLOCK AS REFUGE



TEMPORARY REFUGE



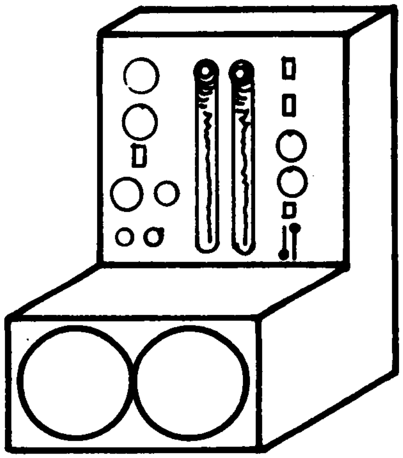
AS LONG TERM REFUGE

POTENTIAL USES

- TEMPORARY FOR SUIT DONNING IN EVENT OF DECOMPRESSION - PROVIDES QUICKEST ROUTE TO SAFETY (16-20 MINUTE OCCUPANCY NEEDED FOR SUIT DONNING)
- TEMPORARY WHILE DEPRESS/REPRESS CABIN OR SORTIE LAB - MUST SIMULTANEOUSLY PURGE AIRLOCK (2 HOUR OCCUPANCY)
- TEMPORARY DURING PURGE WHILE EGRESS FROM CONTAMINATED SORTIE LAB TO CABIN (30 MINUTES TO 1 HOUR OCCUPANCY)
- LONG TERM WHILE WAIT FOR ON-ORBIT RESCUE (96 HOURS)
- TEMPORARY FOR FOOD AND WASTE MANAGEMENT DURING SUITED LONG TERM WAIT

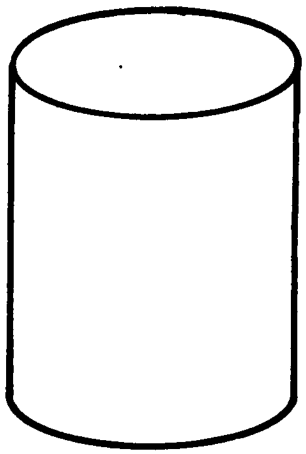
Rev.

AIRLOCK EVA RESCUE CONSIDERATIONS



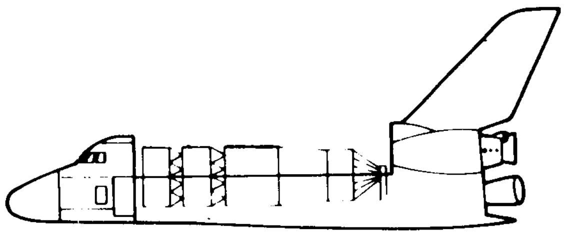
RECHARGE STATION

- LOCATE ONE RECHARGE STATION IN CABIN FOR STANDBY CREWMAN
- REPRESS AIRLOCK AT 6.0 PSI/MIN.
- DESIGN RELIEF VALVE AND AIRLOCK DEPRESS SYSTEM TOGETHER.
- NO REQUIREMENT IDENTIFIED FOR 0 → 3.25 PSIA REPRESS IN 15 SECONDS.

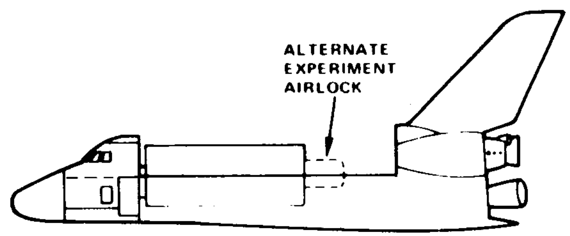


AIRLOCK

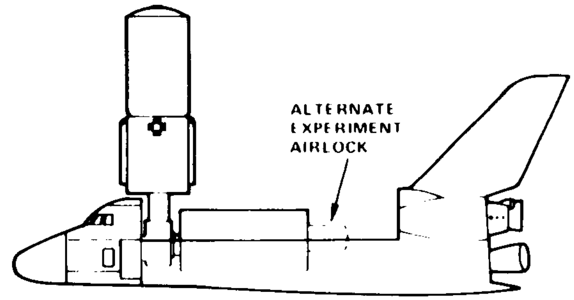
CONTINGENCY EVA ACCESS OPTIONS



- NO DOCKING MODULE
- EVA ACCESS TO AIRLOCK BLOCKED
- NO SORTIE MODULE



- NO DOCKING MODULE
- EVA ACCESS TO AIRLOCK BLOCKED
- SORTIE MODULE IN PLACE (EQUIVALENTLY COULD BE PIVOTED FROM PAYLOAD BAY USING FLEX TUNNEL)



- DOCKING MODULE IN PLACE
- EVA ACCESS TO AIRLOCK BLOCKED
- SORTIE MODULE IN PLACE
- DOCKED TO LARGE OBSERVATORY FOR SERVICING

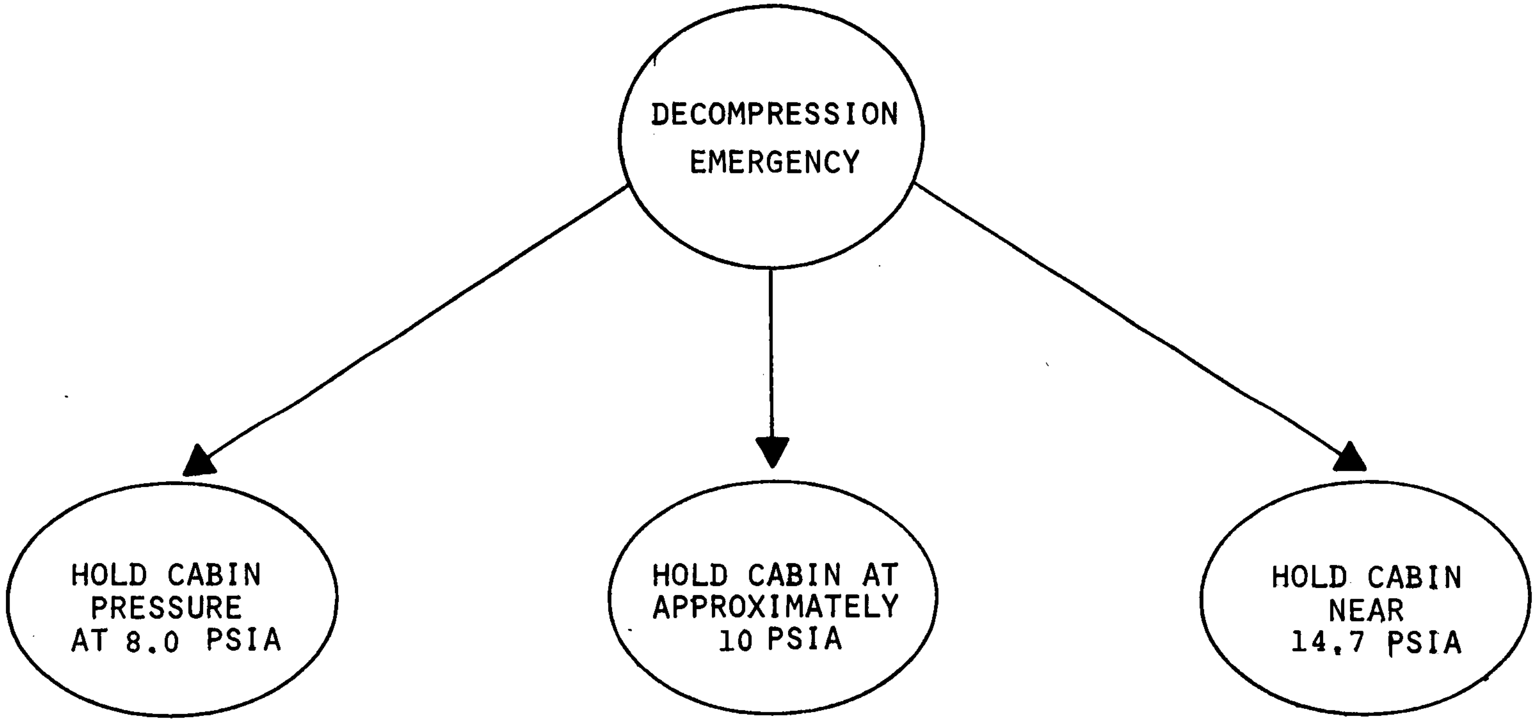
OPTIONS

- JETTISON
- SIDE HATCH USE

- JETTISON SORTIE MODULE
- SIDE HATCH USE
- KICK-OUT HATCH IN SORTIE MODULE
- DISENGAGE SORTIE MODULE TEMPORARILY

- JETTISON LARGE OBSERVATORY
- JETTISON SORTIE MODULE
- JETTISON DOCKING MODULE
- SIDE HATCH USE
- KICK-OUT HATCH
- TEMPORARILY DISENGAGE MODULE

FLOOD FLOW HOLD OPTIONS



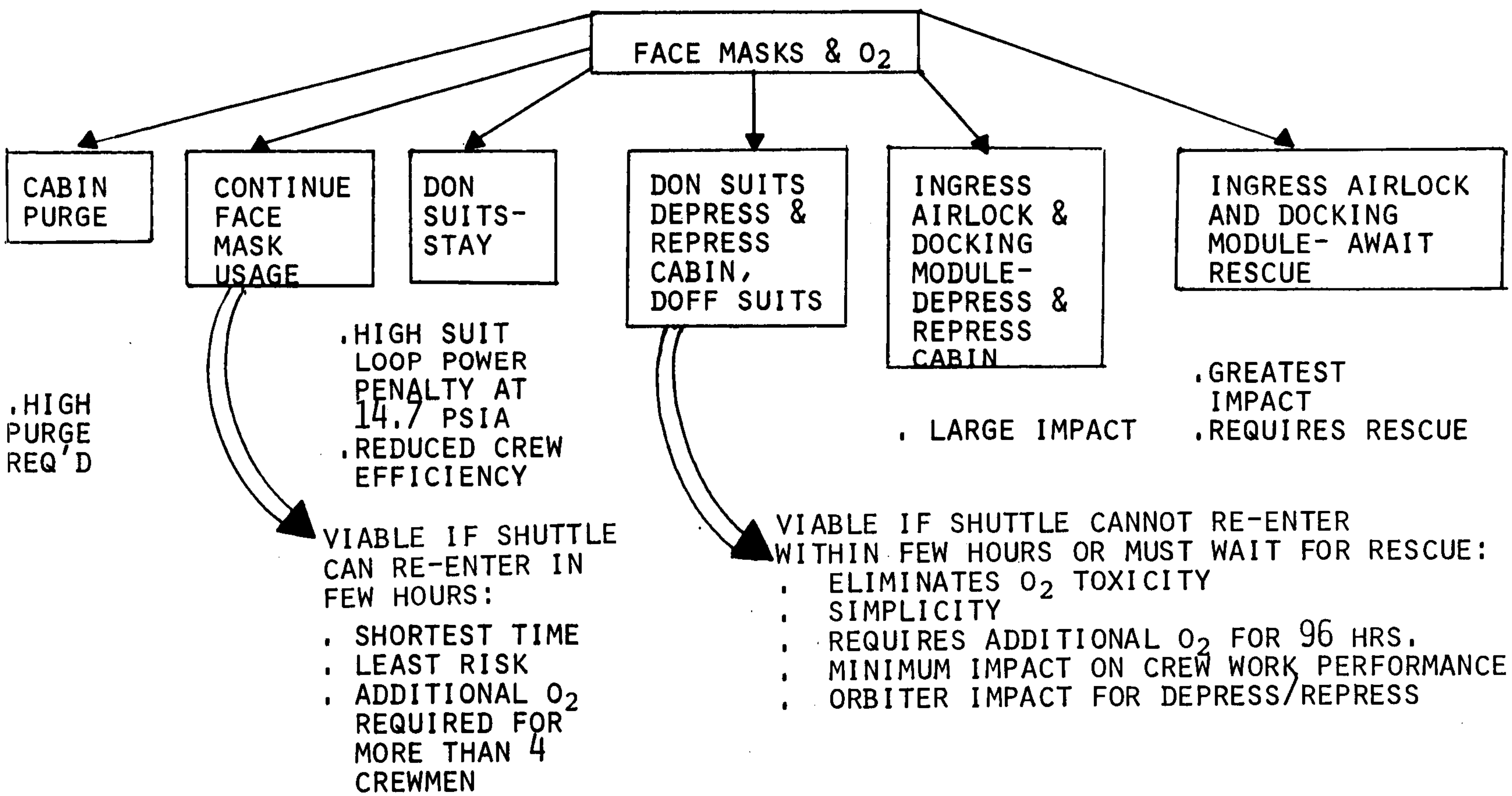
- MAXIMUM DURATION
- HYPOXIA RISK
- STRUCTURAL/VENT IMPACT

- INCREASED DURATION
- ALTERNATE NOMINAL PRESS.
- STRUCTURAL/VENT IMPACT

- SIMPLEST SYSTEM
- HYPOXIA AVOIDED
- PRR BASELINE

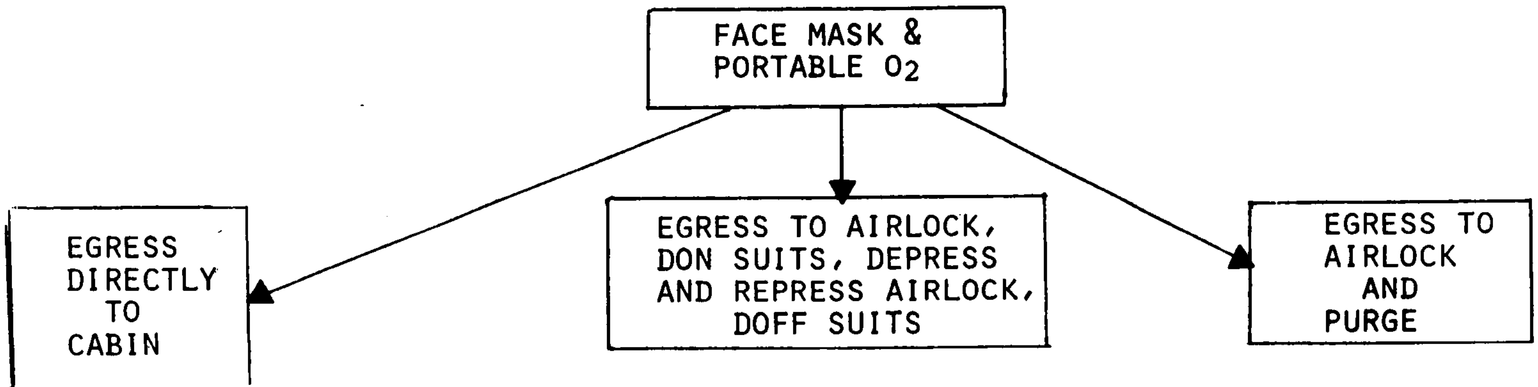
Rev.

CONTAMINATED CABIN OPTIONS



Rev.

SORTIE LAB CONTAMINATION OPTIONS



EGRESS DIRECTLY TO CABIN:

- CABIN CONTAMINATED

EGRESS TO AIRLOCK, DON SUITS, DEPRESS AND REPRESS AIRLOCK, DOFF SUITS:

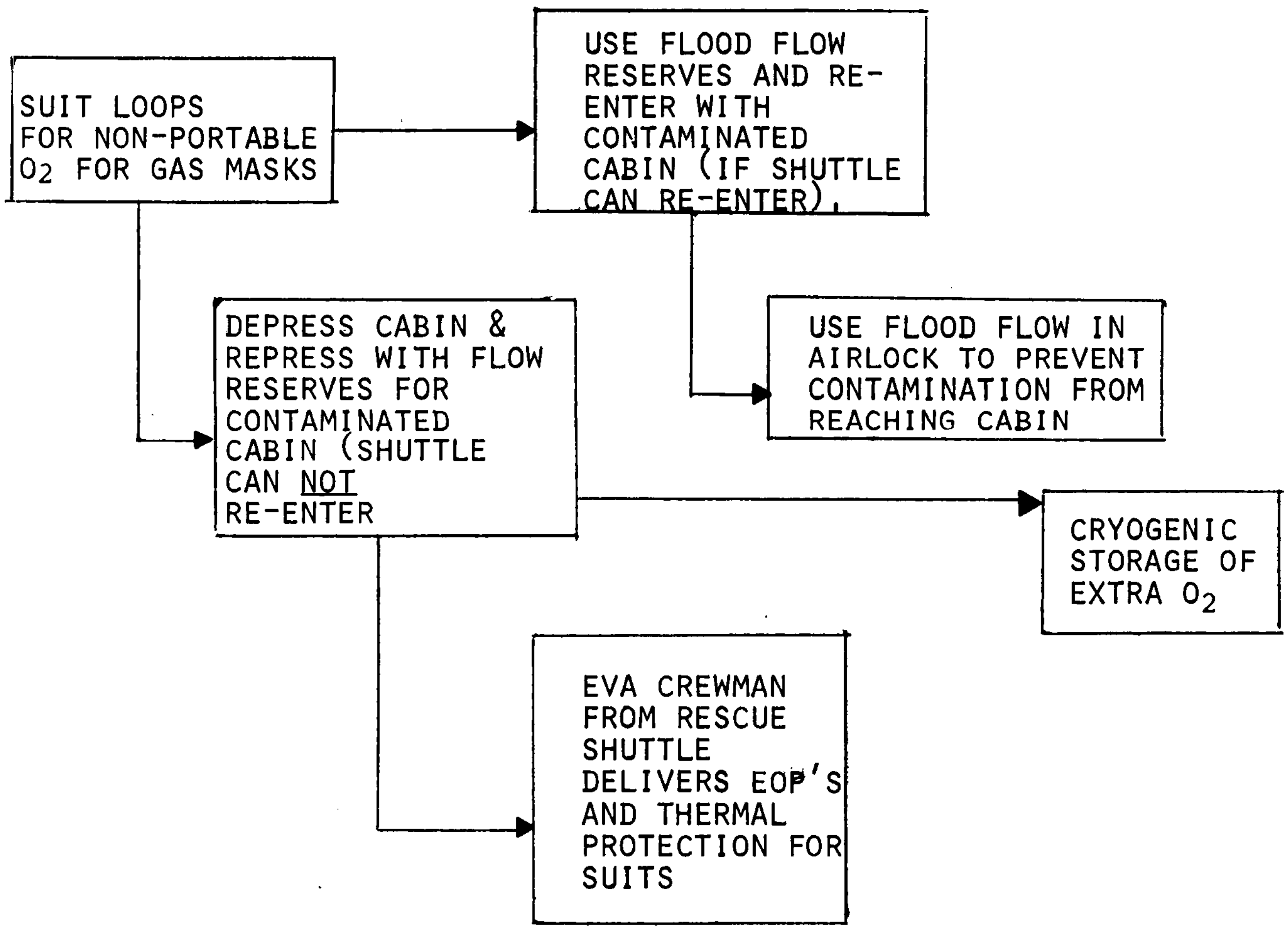
- IV SUITS IN AIRLOCK OR SORTIE LAB
- SUIT LOOPS IN AIRLOCK
- EXTRA TRAINING

EGRESS TO AIRLOCK AND PURGE:

- MINIMAL IMPACT
- CAN USE EOP FOR FACE MASK O_2 SUPPLY
- ACCEPTABLE RESIDUAL CONTAMINATION USING ORBITER PRR PURGE GAS

Rev.

CONTAMINATED CABIN COMMONALITY LOGIC



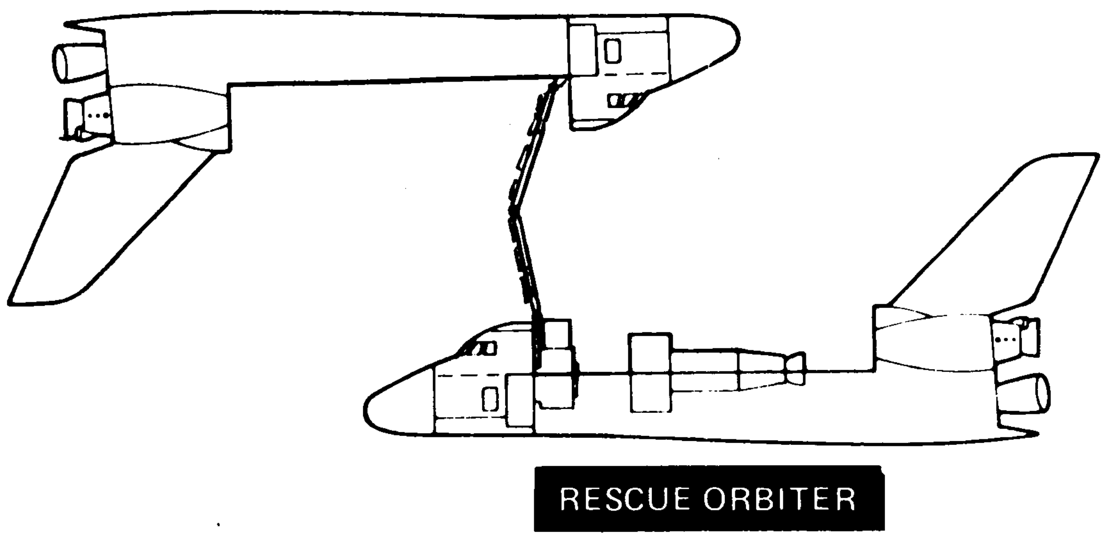
RESCUE ORBITER CONTINGENCY TRANSFER

For any contingency prohibiting re-entry, the preferred mode of survival for the operational phase of the shuttle program is on-orbit rescue. Normally this will be accomplished by direct docking, perhaps with the rescue shuttle bringing up a docking module and adapter. However, if a hard dock is not possible due to lack of stabilization of the disabled vehicle (perhaps because of a cabin depressurization and resultant loss of avionics), or some damage or failure to jettison in the docking area, a contingency EVA transfer will be necessary.

Drift rates due to avionics loss are expected to be small, thus in most instances it is likely that a synchronization maneuver can be accomplished. Then the manipulator arm would be an effective translation aid. Necessary EVA equipment, such as thermal protection for the IV suits, tethers, and EOP's could be brought up by the rescue orbiter.

RESCUE ORBITER CONTINGENCY TRANSFER

DRIVER:
RESCUE ORBITER
CANNOT DOCK



*

RESCUE ORBITER
MUST SYNCHRONIZE
WITH DISABLED
SHUTTLE DRIFT

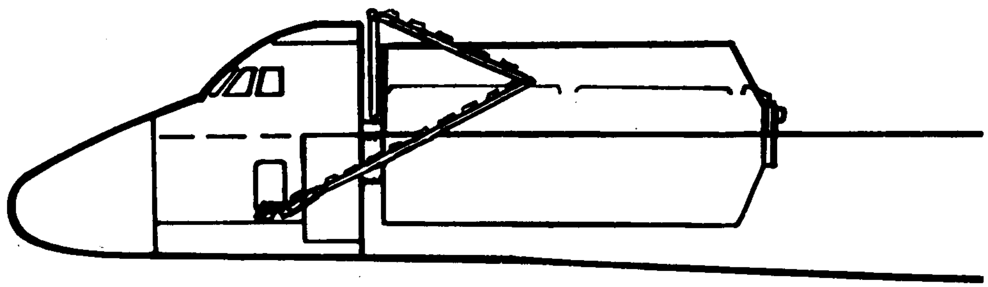
REQUIREMENTS:
- MOBILITY AIDS ON RESCUE MANIPULATOR
- SUITS WITH CONTINGENCY TRANSFER LSS AND THERMAL PROTECTION
- TETHERS
- RESCUE CREWMAN

CONTINGENCY TRANSFER FROM SORTIE MODULE

As illustrated on the opposing page, the impact of blocked IV access from the sortie module to the cabin is great. The credibility of this contingency and the possibility of designing to acceptable risk levels should be studied in more detail. Based on consultation with General Dynamics, it is probable that experiments can be designed/arranged in the sortie module such that blocked access due to an experiment failure would not occur. Then, if all hatches connecting the sortie module and cabin are left open, with only the cabin/airlock hatch closed, it is expected that the risk of blocked access can be made acceptably low by appropriate hatch design. (The cabin/airlock hatch is kept closed to avoid contaminating the cabin.) This precludes EVA during pressurized manned sortie module operation, even if a docking module is present, as safe EVA operation requires an open external hatch.

In addition to the blocked access impacts listed, the cabin must also be depressurized/repressurized, and an umbilical in the cabin from the cabin suit loop must be available to permit assistance to the sortie module crewman performing the contingency transfer.

CONTINGENCY TRANSFER FROM SORTIE MODULE



DRIVER:
BLOCKED
IV ACCESS

MAJOR IMPACT:
- CONTINGENCY TRANSFER SUITS, LSS, THERMAL PROTECTION, AND TETHER IN SORTIE MODULE
- REMOTE SECOND HATCH ON SORTIE MODULE
- CONTINGENCY LSS IN SORTIE MODULE
- MOBILITY AIDS AND SIDE HATCH USE
- RESEAL SIDE HATCH BEFORE RE-ENTER

RECOMMEND:
- DESIGN TO ACCEPTABLE RISK OF NO BLOCKED ACCESS
- OPERATE SORTIE MODULE AND AIRLOCK/SORTIE MODULE HATCHES OPEN
- OPERATE CABIN/AIRLOCK HATCH CLOSED

Rev.

BLOCKED ACCESS IN AIRLOCK

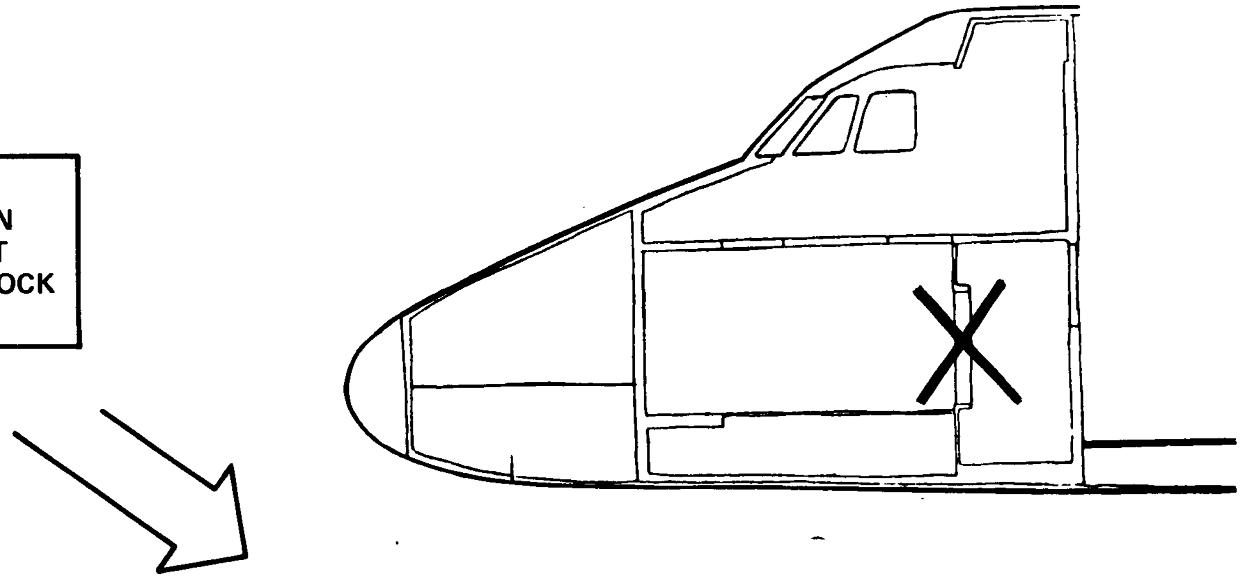
This contingency includes various ways of blocking EVA return as described previously under Class VI. The illustrated case is for a cabin hatch failure to open.

Similar to the case of blocked access from the sortie module, it is expected that this contingency can be reduced to an acceptable risk level by appropriate design. EVA would always be conducted with external hatches open, thus precluding simultaneous manned sortie module operation (unless by IVA).

Rev.

BLOCKED ACCESS IN AIRLOCK

DRIVER:
EVA RETURN
BLOCKED AT
CABIN/AIRLOCK
HATCH



IMPACT:
- CONTINGENCY LSS IN AIRLOCK
- MOBILITY AIDS AND SIDE HATCH USE

RECOMMEND:
- DESIGN FOR ACCEPTABLE RISK OF NO BLOCKAGE

DEVELOPMENT FLIGHTS

During development flights and until the shuttle program becomes operational to the extent that on-orbit rescue is feasible, survival will not be possible with any contingency precluding re-entry. In addition, risks are greater. This demands building all the safety reasonably possible into early flights. Since EVA is an important inspection/repair tool, it is certainly required at this stage.

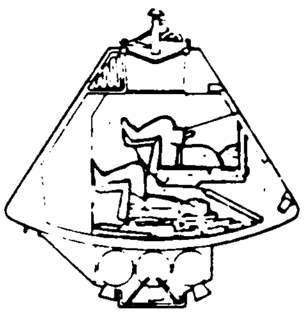
The Rockwell "Safety in Earth Orbit" study determined that an excape capsule is preferred over a ground based rescue attempt, and they recommended a modified Apollo Command Module. In addition, because of excess cargo area likely to be available, additional purge gas could be stored to extend the response/repair time to any emergency. The basic recommendation here is an escape capsule, to be discussed in more detail in a subsequent chart.

DEVELOPMENT FLIGHTS

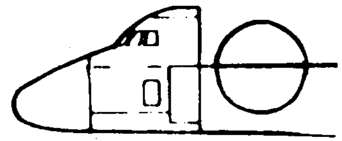
CONSIDERATIONS:
- NO RESCUE SHUTTLE
- HIGHER RISKS
- EXCESS PAYLOAD CAPACITY
- SHORT DEVELOPMENT PHASE

OPTIONS:

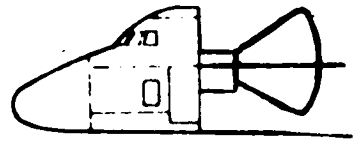
APOLLO COMMAND MODULE



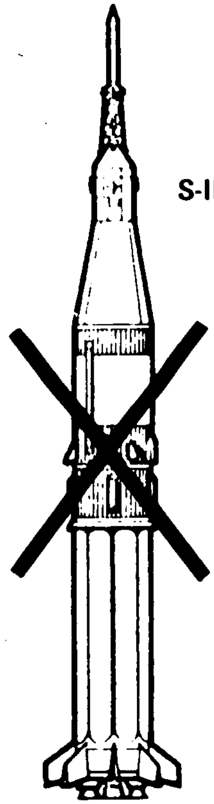
- ADDITIONAL PURGE OXYGEN/NITROGEN



- ESCAPE CAPSULE



- GROUND BASED RESCUE
- ~~TAKE THE RISK~~



Rev.

RECOMMENDATIONS

- RECOMMENDED CONCEPT
  - ALTERNATE EMERGENCY CONCEPT
    - ESCAPE CAPSULE FOR DEVELOPMENT FLIGHTS
      - RECOMMENDED SORTIE MODULE EMERGENCY PROVISIONS

RECOMMENDED CONCEPT

The opposing chart briefly summarizes the recommended requirements for the orbiter and sortie module (given in the common requirements set) during the operational phase. The recommendations are basically the same for the 3 hour, 10 hour, and 96 hour cases.

All crewmen are normally in the shirtsleeve configuration. EVA suits and life support systems are provided for two crewmen, and IV suits are provided in the cabin for all others on board. Gas masks and oxygen are provided for all, where the 2 EOP's double as portable oxygen containers. Fire extinguishers and protective garments are provided in all manned compartments. Contingency transfer capability is brought up by the rescue orbiter.

Suits are donned or panic mode re-entry is initiated as soon as a pressure loss failure is sensed, and adequate flood flow is provided to hold pressure. Integral suit loops are provided.

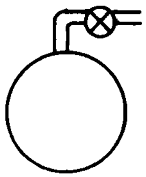
Rev.

RECOMMENDED CONCEPT

EOP

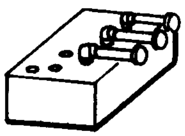
- TWO ON BOARD FOR EVA
- CONTINGENCY TRANSFER (RESCUE ORBITER BRINGS EXTRAS)
- GAS MASK PORTABLE OXYGEN (10 MIN.)
- 96 HR STAY OXYGEN SUPPLEMENT

ADDITIONAL TANKAGE



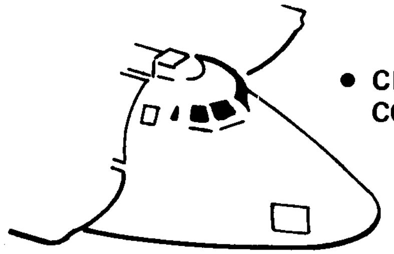
- DEPRESS/REPRESS PURGE + 96 HR WAIT (>2 MEN)
- NON-PORTABLE GAS MASK OXYGEN SOURCE FOR SUIT DON (24 MIN.)
- FLOOD FLOW

SUIT LOOPS AND SUITS



- CONTINGENCY LSS, CABIN
- OXYGEN SUPPLY FOR NON-PORTABLE GAS MASKS
- TWO EVA SUITS & EVLSS
- IV SUITS FOR OTHERS

CABIN DEPRESS/REPRESS CAPABILITY

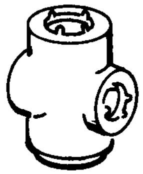


- CLEAR CONTAMINATION

FLOOD FLOW

- HOLD CABIN PRESSURE FOR SUIT DON OR PANIC MODE SHIRTSLEEVE RE-ENTRY

CONTINGENCY TRANSFER



- RESCUE SHUTTLE FOR ORBITAL RESCUE
- MOBILITY AIDS ON MANIPULATOR
- POSSIBLE MODIFIED DOCKING MODULE

COMMON REQUIREMENTS SET

Rev.

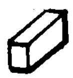
ALTERNATE EMERGENCY CONCEPT

If the shuttle can re-enter unpressurized in 3 hours, the simple EVLSS carry-on emergency LSS concept becomes viable. The joint requirement is that adequate flood flow be guaranteed to hold cabin pressure for 23 minutes during suit don (with LCG in all suits), or that the airlock must be enlarged and modified so that more than 2 can use it for donning suits plus EVLSS's. The distinct advantage is very low scar, although the total launch penalty is high for 4 or more crewmen. Another major advantage is in contingency equipment commonality with EVA equipment. The potential drawback is vehicle cost impact to permit unpressurized re-entry. Further study is needed, although current estimates by NR indicate that the unpressurized re-entry capability is prohibitively expensive.

ALTERNATE EMERGENCY CONCEPT

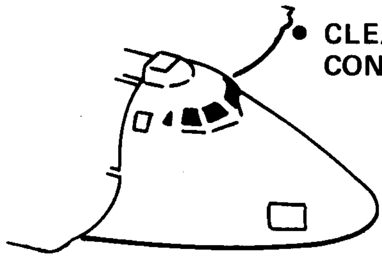
3 HOUR — SHUTTLE CAN RE-ENTER UNPRESSURIZED

EOP



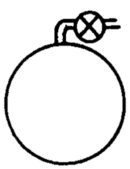
- 1 EACH PERSON
- EVA
- CONTINGENCY TRANSFER
- GAS MASK OXYGEN (ALL USES)
- 96 HR STAY OXYGEN SUPPLEMENT

CABIN DEPRESS/REPRESS CAPABILITY



- CLEAR CONTAMINATION

ADDITIONAL TANKAGE

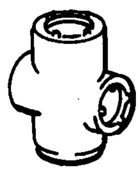


- DEPRESS/REPRESS PURGE + 96 HR WAIT

FLOOD FLOW

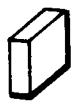
- HOLD CABIN PRESSURE FOR SUIT DON

DOCKING MODULE



- DELIVERED BY RESCUE SHUTTLE

EVLSS AND VEHICLE WATER UMBILICALS



- CONTINGENCY LSS (1 EACH)
- EVA (2)
- LCG REQUIRED IN ALL IV SUITS

COMMON REQUIREMENTS SET

Rev.

ESCAPE CAPSULE FOR DEVELOPMENT FLIGHTS

Rockwell evaluated the Apollo command module (CM) for use as an escape capsule, and recommended a modified version to support 6 men at an 8 psia oxygen pressure. A retro-rocket package would be added, or extra RCS tankage would be provided.

Because present studies have determined the need for contingency EVA equipment, the escape capsule requirements are somewhat changed. First, an adapter with an EVA hatch would be required. Second, prebreathing could be accomplished (about 2 hours) using the EVLSS, and the standard 5 psia CM atmosphere could be retained. If 3 or fewer men are used during development flights, the standard seating could be retained. Various other options, such as the Skylab rescue configuration (5 men) are, of course, open.

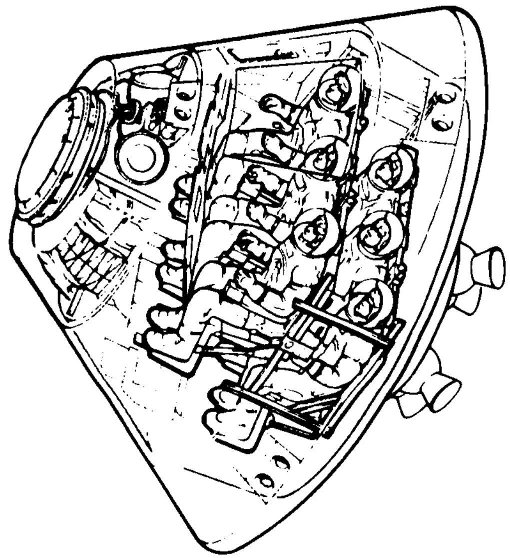
By requiring suits and EVLSS's for each crewman and donning space in the airlock/adapter, no other contingency LSS is required. The vehicle airlock water loop is used for thermal control during any temporary airlock refuge greater than 47 minutes for 4 men, which is adequate time to don the suits.

The cabin depress/repress capability is again recommended, and additional flood flow gas is highly desirable to extend the time duration available for any repair operations.

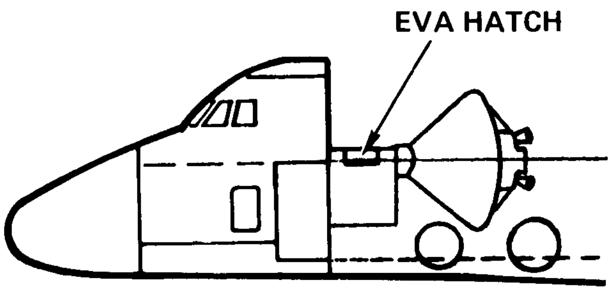
ESCAPE CAPSULE FOR DEVELOPMENT FLIGHTS

APOLLO COMMAND MODULE

- 5 PSIA O_2
- 3-MAN BASIC CREW
- STRAP ON RETRO ROCKETS
- ALTERNATE 6-MAN MODIFICATION
- ADAPTER/EVA AIRLOCK HATCH
- 10,000 – 15,000 LB



CABIN DEPRESS/REPRESS CAPABILITY

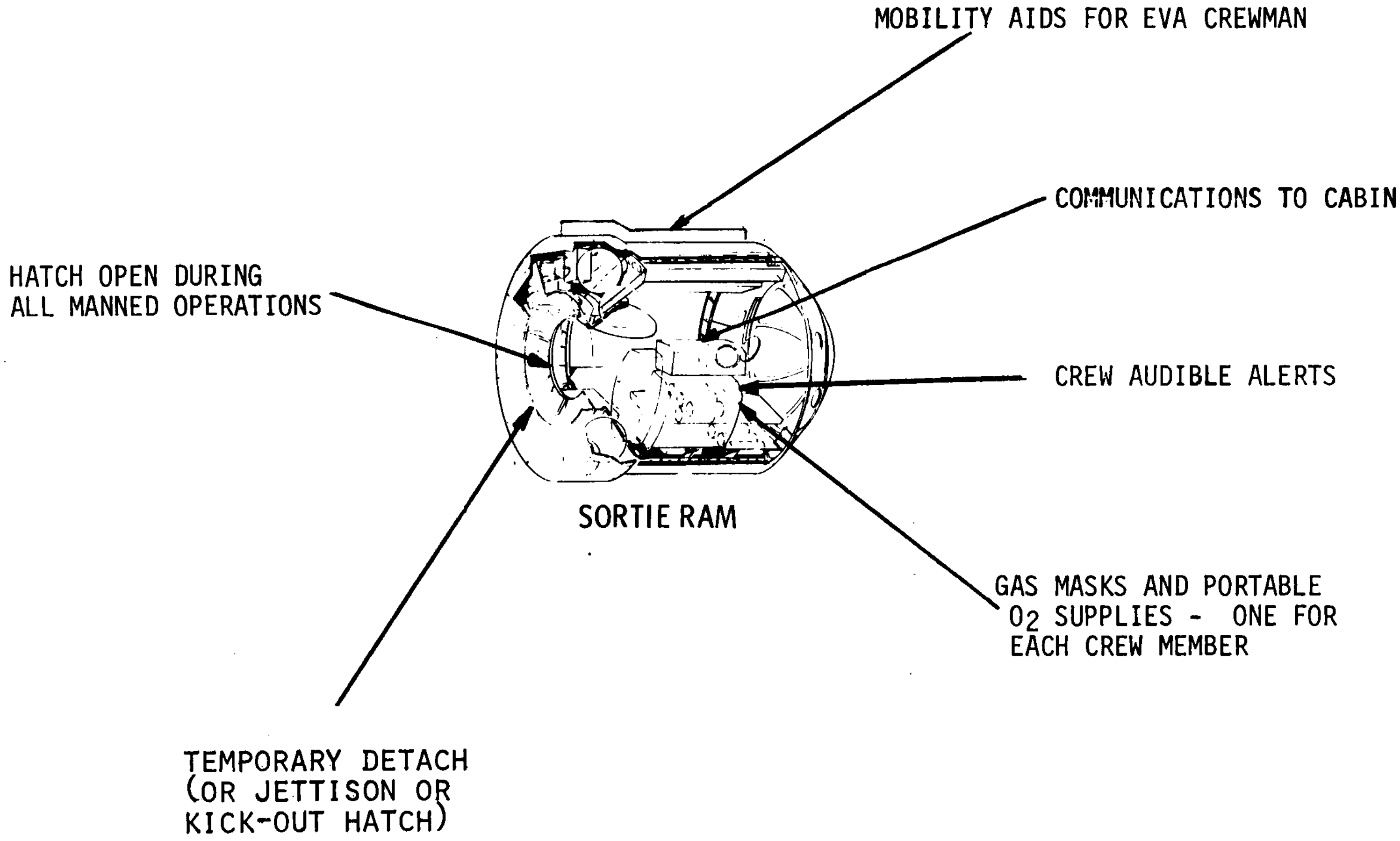


COMMON REQUIREMENTS SET

NO CONTINGENCY LSS REQUIRED*

ADDITIONAL OXYGEN/NITROGEN FLOOD FLOW

RECOMMENDED SORTIE MODULE EMERGENCY PROVISIONS



SORTIE RAM

APPENDIX A

APPENDIX A

EQUIPMENT REQUIREMENTS BY SCENARIO

This appendix presents the equipment required for each of the 28 scenarios. The enclosed tables contain a list of all equipment and identify the items required for each emergency class. Appendix B presents a functional description of each item.

CLASS I EQUIPMENT REQUIREMENTS

FIRE OR RELEASE OF TOXIC SUBSTANCES

ITEM	SCENARIO: FIRE CONTAMINATES CABIN I-a-A	I-a-B	FIRE IN CARGO BAY I-b	FIRE IN SORTIE MODULE I-c-A	I-c-B
1 Crew Audible Alert	X	X	X	X	X
2 Gas Mask & O_2, Portable	Cabin	Cabin		Sortie	Sortie
3 Airlock as refuge		(Optional)			
4 Pressure Suits		All Peron.	EVA Crew		
5 Fire Extinguishers	X-Cabin	X-Cabin		Sortie	Sortie
6 Depressuirzation		Cabin			
7 Repressurization		Cabin			
8 Jettison			Cargo		
9 Leak Repair Kit					
10 Portable Cont. LSS					
11 EVLSS as Normal EVA			X		
12 Flood Flow, Low					X-Airlock
13 Flood Flow, High					
14 Comm. to Ground	X	X-Cabin	Cabin	X-Cabin	X-Cabin
15 Comm. To Suited Man		X			
16 Thermal Protective Garment			EVA Crew		
17 Rescue Umbilical					
18 Manipulator as Translator					
19 Mobility Aids					
20 Gas Masks & O_2 - 3 Hrs	All	All		All	Sortie
21 Cont. LSS - 3 Hrs or 10 Hrs					
22 96 Hr. Cont. LSS, Suited Man					
23 Umbilical in Cabin					
24 1.7 Hr Cont. LSS, Suited Man					
25 Comm. Cabin/Sortie Lab					
26 Ingress Aid to Side Hatch					
27 Computer Assist Decision Aid	X	X	X	X	X
28 Alert of Near Exhaust Purge Flow					
29 Repair Kits					
30 Tether & Tether Attach Points			X		

CLASS II EQUIPMENT REQUIREMENTS EXPLOSION SCENARIO

ITEM	EXPLOSION IN CABIN, SHUTTLE CAN NOT RE-ENTER II-a-A	II-a-B	EXPLOSION IN SORTIE MODULE WITH BLOCKED ACCESS II-b	EXPLOSION & DECOMPRESSION IN SORTIE MODULE II-c
1 Crew Audible Alert	X	X	X	Same as I-c and III-c with additional requirement for cabin personnel to assist in egress of injured personnel from sortie module
2 Gas Mask & O_2, Portable	X	X	1 ea.-Sortie	
3 Airlock as refuge				
4 Pressure Suits	All	All	All	
5 Fire Extinguishers	Cabin	Cabin	Sortie	
6 Depressuirzation	Cabin		Cabin & Sortie	
7 Repressurization	Cabin		Cabin	
8 Jettison				
9 Leak Repair Kit				
10 Portable Cont. LSS	2-Cabin		2 - Sortie	
11 EVLSS as Normal EVA				
12 Flood Flow, Low	Cabin			
13 Flood Flow, High				
14 Comm. to Ground	Cabin	Cabin	Cabin	
15 Comm. To Suited Man	Cabin	Cabin	Cabin/EVA	
16 Thermal Protective Garment			Sortie	
17 Rescue Umbilical			X	
18 Manipulator as Translator			Partial (1)	
19 Mobility Aids			X	
20 Gas Masks & O_2 - 3 Hrs		All-50 Min.		
21 Cont. LSS - 3 Hrs or 10 Hrs	All		All	
22 96 Hr. Cont. LSS, Suited Man		All		
23 Umbilical in Cabin		X		
24 1.7 Hr Cont. LSS, Suited Man			Sortie	
25 Comm. Cabin/Sortie Lab			X	
26 Ingress Aid to Side Hatch			X	
27 Computer Assist Decision Aid	X	X	X	
28 Alert of Near Exhaust Purge Flow				
29 Repair Kits				
30 Tether & Tether Attach Points			X	

(1) Mainpulator may be used as a fixed position rail when cabin depressurized.

CLASS III EQUIPMENT REQUIREMENTS DECOMPRESSION

SCENARIO

ITEM	REPAIR LEAK IN CABIN III-a-A	REPAIR LEAK IN CABIN III-a-B	UNREPARABLE LEAK IN CABIN III-b-A	UNREPARABLE LEAK IN CABIN III-b-B	LEAK IN SORTIE MODULE III-c
1 Crew Audible Alert	X	X	X	X	X
2 Gas Mask & O_2, Portable					
3 Airlock as refuge					
4 Pressure Suits	All	All	All	All	
5 Fire Extinguishers					
6 Depressuirzation					Sortie
7 Repressurization					
8 Jettison		Cargo(2)		Cargo(2)	
9 Leak Repair Kit	Cabin	Cabin	Cabin	Cabin	
10 Portable Cont. LSS	2-Cabin	2-Cabin	2-Cabin	2-Cabin	
11 EVLSS as Normal EVA					
12 Flood Flow, Low	Cabin	Cabin	Cabin	Cabin	Sortie
13 Flood Flow, High					
14 Comm. to Ground	Cabin	Cabin	Cabin	Cabin	Cabin
15 Comm. To Suited Man	Cabin	Cabin	Cabin	Cabin	
16 Thermal Protective Garment			All(1)		
17 Rescue Umbilical					
18 Manipulator as Translator					
19 Mobility Aids					
20 Gas Masks & O_2 - 3 Hrs					
21 Cont. LSS - 3 Hrs or 10 Hrs	All	All-cabin		All-cabin	
22 96 Hr. Cont. LSS, Suited Man			Cabin		
23 Umbilical in Cabin		10 ft(2)	10 ft	10 ft(2)	
24 1.7 Hr Cont. LSS, Suited Man					
25 Comm. Cabin/Sortie Lab					
26 Ingress Aid to Side Hatch					
27 Computer Assist Decision Aid	X	X	X	X	X
28 Alert of Near Exhaust Purge Flow	X	X	X	X	
29 Repair Kits					
30 Tether & Tether Attach Points					

(1) If docking module is not on flight
(2) Cargo jettison may be required to allow re-entry within available time

CLASS IV EQUIPMENT REQUIREMENTS INTERNAL HATCH
FAILURE OR BLOCKED ACCESS PATH

SCENARIO

ITEM	DOCKING MODULE NOT AVAILABLE IV-a-A	DOCKING MODULE NOT AVAILABLE IV-a-B	DOCKING MODULE AVAILABLE IV-b
1 Crew Audible Alert	X	X	X
2 Gas Mask & O_2, Portable			
3 Airlock as refuge	(Optional)	(Optional)	
4 Pressure Suits	All	All	All
5 Fire Extinguishers			
6 Depressuirzation	Cabin & Sortie	Cabin & Sortie	Sortie
7 Repressurization	Cabin	Cabin	
8 Jettison	Tether	Tether	Tether
9 Leak Repair Kit			
10 Portable Cont. LSS	Sortie	Sortie	1-Sortie
11 EVLSS as Normal EVA			
12 Flood Flow, Low			
13 Flood Flow, High			
14 Comm. to Ground	Cabin	Cabin	Cabin
15 Comm. To Suited Man	Cabin to EVA	Cabin to EVA	Cabin/EVA
16 Thermal Protective Garment	Sortie	Sortie	Sortie
17 Rescue Umbilical		X	
18 Manipulator as Translator	Partial	X	X
19 Mobility Aids		X	X
20 Gas Masks & O_2 - 3 Hrs			
21 Cont. LSS - 3 Hrs or 10 Hrs	All	All	All
22 96 Hr. Cont. LSS, Suited Man			
23 Umbilical in Cabin	10 Ft	10 Ft,	
24 1.7 Hr Cont. LSS, Suited Man	Sortie	Sortie	Sortie
25 Comm. Cabin/Sortie Lab	X	X	X
26 Ingress Aid to Side Hatch	X	X	
27 Computer Assist Decision Aid	X	X	X
28 Alert of Near Exhaust Purge Flow			
29 Repair Kits			
30 Tether & Tether Attach Points	X	X	X

CLASS V EQUIPMENT REQUIREMENTS
FAILURE TO DOCK/UNDOCK

ITEM	SCENARIO: FAILURE OF RESCUE SHUTTLE TO DOCK (1) V-a	FAILURE TO UNDOCK FREE-FLYER V-b
1 Crew Audible Alert	X	X
2 Gas Mask & O_2, Portable		
3 Airlock as refuge		
4 Pressure Suits	All	EVA Crew
5 Fire Extinguishers		
6 Depressuirzation		
7 Repressurization		
8 Jettison	X - CARGO	F.F. Sortie
9 Leak Repair Kit		
10 Portable Cont. LSS	All	
11 EVLSS as Normal EVA		X
12 Flood Flow, Low		
13 Flood Flow, High		
14 Comm. to Ground	Cabin	Cabin
15 Comm. To Suited Man	Cabin/EVA	Cabin/EVA
16 Thermal Protective Garment	All	EVA Crew
17 Rescue Umbilical		
18 Manipulator as Translator	X-Rescue Shuttle	X
19 Mobility Aids		
20 Gas Masks & O_2 - 3 Hrs		
21 Cont. LSS - 3 Hrs or 10 Hrs	All - Cabin	
22 96 Hr. Cont. LSS, Suited Man		
23 Umbilical in Cabin		
24 1.7 Hr Cont. LSS, Suited Man		
25 Comm. Cabin/Sortie Lab		
26 Ingress Aid to Side Hatch		
27 Computer Assist Decision Aid	X	X
28 Alert of Near Exhaust Purge Flow		
29 Repair Kits		
30 Tether & Tether Attach Points	X	X

(1) Occurs with Class II and Class III emergencies as a result of the same failure (not a double failure)

CLASS VI EQUIPMENT REQUIREMENTS
FAILURE OF AIRLOCK OR OTHER EXTERNAL HATCH

ITEM	SCENARIO: EVA HATCH FAIL TO SEAL VI-a	HATCH TO CABIN FAIL TO OPEN VI-b
1 Crew Audible Alert	X	X
2 Gas Mask & O_2, Portable		
3 Airlock as refuge		
4 Pressure Suits	EVA Crew	All
5 Fire Extinguishers		
6 Depressuirzation		Cabin
7 Repressurization		Cabin
8 Jettison		
9 Leak Repair Kit	Airlock	
10 Portable Cont. LSS	EVA Crew	EVA Crew
11 EVLSS as Normal EVA		
12 Flood Flow, Low	Cabin	
13 Flood Flow, High	Airlock	
14 Comm. to Ground	Cabin	Cabin
15 Comm. To Suited Man	In Airlock	In Airlock
16 Thermal Protective Garment		EVA Crew
17 Rescue Umbilical		
18 Manipulator as Translator		Partial
19 Mobility Aids		
20 Gas Masks & O_2 - 3 Hrs		
21 Cont. LSS - 3 Hrs or 10 Hrs		In Airlock
22 96 Hr. Cont. LSS, Suited Man		
23 Umbilical in Cabin		
24 1.7 Hr Cont. LSS, Suited Man		
25 Comm. Cabin/Sortie Lab		
26 Ingress Aid to Side Hatch		X
27 Computer Assist Decision Aid	X	X
28 Alert of Near Exhaust Purge Flow	X	
29 Repair Kits		
30 Tether & Tether Attach Points		

CLASS VII EQUIPMENT REQUIREMENTS
INSPECT/REPAIR SHUTTLE EXTERNAL DAMAGE

ITEM	SCENARIO TPS INSPECTION VII-a
1 Crew Audible Alert	X
2 Gas Mask & O_2, Portable	
3 Airlock as refuge	
4 Pressure Suits	EVA Crew
5 Fire Extinguishers	
6 Depressuirzation	
7 Repressurization	
8 Jettison	X
9 Leak Repair Kit	
10 Portable Cont. LSS	
11 EVLSS as Normal EVA	X
12 Flood Flow, Low	
13 Flood Flow, High	
14 Comm. to Ground	X
15 Comm. To Suited Man	X
16 Thermal Protective Garment	
17 Rescue Umbilical	
18 Manipulator as Translator	X
19 Mobility Aids	X
20 Gas Masks & O_2 - 3 Hrs	
21 Cont. LSS - 3 Hrs or 10 Hrs	
22 96 Hr. Cont. LSS, Suited Man	
23 Umbilical in Cabin	
24 1.7 Hr Cont. LSS, Suited Man	
25 Comm. Cabin/Sortie Lab	
26 Ingress Aid to Side Hatch	
27 Computer Assist Decision Aid	X
28 Alert of Near Exhaust Purge Flow	
29 Repair Kits	X
30 Tether & Tether Attach Points	

CLASS VIII EQUIPMENT REQUIREMENTS
DISABLED EVA/IVA CREWMAN

ITEM	SCENARIO: DISABLED, DRIFTED EVA CREWMAN — Two Man VII-a-A	DISABLED, DRIFTED EVA CREWMAN — One Man VII-a-B	MANIPULATOR MALFUNCTION DISABLED EVA CREWMAN — Two Man VII-b-A	MANIPULATOR MALFUNCTION DISABLED EVA CREWMAN — One Man VII-b-B	DISABLED IVA CREWMAN — Two Man VII-c-A	DISABLED IVA CREWMAN — One Man VII-c-B
1 Crew Audible Alert	X	X	X	X	X	X
2 Gas Mask & O_2, Portable						
3 Airlock as refuge						
4 Pressure Suits	EVA Crew	EVA Crew	EVA Crew	EVA Crew	IVA Crew	IVA Crew
5 Fire Extinguishers						
6 Depressuirzation	Airlock	Airlock	Airlock	Airlock	Airlock	Airlock
7 Repressurization	Airlock	Airlock	Airlock	Airlock	Airlock	Airlock
8 Jettison	Tether	Tether	Tether	Tether		
9 Leak Repair Kit						
10 Portable Cont. LSS	EVA Crew	EVA Crew	EVA Crew	EVA Crew	IVA Crew	IVA Crew
11 EVLSS as Normal EVA						
12 Flood Flow, Low						
13 Flood Flow, High	Airlock	Airlock	Airlock	Airlock	Dock,Mod, Airlock	Dock,Mod, Airlock
14 Comm. to Ground	Cabin	Cabin	Cabin		Cabin	
15 Comm. To Suited Man	EVA/Cabin	EVA/Cabin	EVA/Cabin	EVA/Cabin	IVA/Cabin	IVA/Cabin
16 Thermal Protective Garment	EVA Crew	EVA Crew	EVA Crew	EVA Crew		
17 Rescue Umbilical						
18 Manipulator as Translator	(Optional)	(Optional)	X	X		
19 Mobility Aids	X	X				
20 Gas Masks & O_2 - 3 Hrs						
21 Cont. LSS - 3 Hrs or 10 Hrs						
22 96 Hr. Cont. LSS, Suited Man						
23 Umbilical in Cabin						
24 1.7 Hr Cont. LSS, Suited Man						
25 Comm. Cabin/Sortie Lab						
26 Ingress Aid to Side Hatch						
27 Computer Assist Decision Aid	X	X	X	X	X	X
28 Alert of Near Exhaust Purge Flow						
29 Repair Kits						
30 Tether & Tether Attach Points	X	X	X	X		

APPENDIX B

APPENDIX B

FUNCTIONAL DESCRIPTION OF EMERGENCY ITEMS

This Appendix presents the functional description of each emergency item. The identification number corresponds to the item number in the tables of Appendix A.

Each of the enclosed tables describes the function of one or more items. Some of the items have been combined when the items are similar or may be made as a single item.

EQUIPMENT REQUIREMENTS

ITEM: #1 Crew Audible Alert

#28 Alert of Near Exhaustion of Flood Flow

LOCATION(S): Cabin, Airlock, Sortie Module

FLIGHT REQUIREMENTS: ALL (SCAR) Scar; CARRY-ON Sortie Module

NUMBER REQUIRED: one, central

DURATION: T.B.D. HOURS

FUNCTIONAL REQUIREMENTS:

1) Automatic Detection
   a) Decompression
   b) Fire
   c) Toxic Gasses
   d) Exhaustion of emergency reserves
2) Warning Signal, Simultaneously to All
   a) Cabin upper and lower decks
   b) Airlock
   c) Sortie Module
3) Manually shut down of alarm
   (For planned depressurizations)
4) Airlock Only Provisions
   a) Failure to hold pressure
   b) Failure to decompress
5) Alert of near exhaustion of flood flow

EQUIPMENT REQUIREMENTS

ITEM: #2 Gas Masks and O_2 Supply Portable

#20 And O_2 Supply, Non-Portable

LOCATION(S): Cabin
Sortie Module

FLIGHT REQUIREMENTS: ALL (SCAR) Minimum Crew Size
CARRY-ON To All Personnel Total

NUMBER REQUIRED: TBD For Each Flight

DURATION: up to 10 HOURS

FUNCTIONAL REQUIREMENTS:

1) Gas Mask (A-21 Military System Currently Baselined)

   a) There are advantages for use with an 8.0 psi regulated O_2 or air source (i.e., EOP or suit loops)
   b) Use with a portable O_2 supply and a non-portable supply in one flight
   c) Storage for minimum don time

2) Portable O_2 Supply

   a) 10-45 minutes minimum duration
   b) only minimum crew size as scar (two)
   c) All personnel in sortie module

3) Non-Portable O_2 Supply

   a) Limited to 10 hours with pure O_2
   b) One for all personnel
   c) Scar one each for minimum crew size
   d) Minimum use time of 3.0 hours

EQUIPMENT REQUIREMENTS

ITEM: # 3 Airlock as Refuge (Optional, not identified as a firm requirement)

LOCATION(S): Airlock

FLIGHT REQUIREMENTS: ALL (SCAR) CARRY-ON Scar

NUMBER REQUIRED: 1

DURATION: T.B.D. HOURS

FUNCTIONAL REQUIREMENTS:

On decompression, fire and explosion contingencies, additional repair time can be obtained if the crewman can use the airlock as a temporary refuge. Two men can use the airlock to don a pressure suit,but a LSS transfer is necessary to connect to the cabin systems.

1) LSS in airlock for two men
2) Umbilical in airlock to transfer to cabin LSS

Non-Requirement: For 96 hour contingencies the penalties for venting the airlock make it undesirable to use as a station for food, drink and personal hygiene during a contingency requiring use of suit loops.

EQUIPMENT REQUIREMENTS

ITEM: # 4 Pressure Suits

LOCATION(S): Cabin
Sortie Module

FLIGHT REQUIREMENTS: ALL (SCAR) Minimum crew size
CARRY-ON All

NUMBER REQUIRED: one each, all personnel

DURATION: 3,10,96 HOURS

FUNCTIONAL REQUIREMENTS:

1) Mobility: See ILC Report
   a) EVA suit (2 as SCAR)
   b) IVA pilot and commander (may be EVA suits)
   c) Passengers
2) Communications Carrier Assembly Required
3) Urine transfer Assembly all suits
4) 96 Hour Suited Operations, Pressurized
   a) Food
   b) Water — If airlock can not be used as refuge
   c) Fecal management
5) 3 & 10 Hr. Suited Operations, Pressurized
   a) Water
   b) Minimum amount of fecal management (i.e., same as EVA system)

EQUIPMENT REQUIREMENTS

ITEM: #5 Fire Extinguishers

LOCATION(S): Cabin
Sortie Module

FLIGHT REQUIREMENTS: ALL (SCAR) Cabin
CARRY-ON Sortie Module

NUMBER REQUIRED: TBD

DURATION: N.A. HOURS

FUNCTIONAL REQUIREMENTS:

1) Type, size, and locations T.B.D.

EQUIPMENT REQUIREMENTS

ITEM: #6 Depressurization

LOCATION(S): Cabin
(Airlock Inherent)
Sortie Module

FLIGHT REQUIREMENTS: ALL (SCAR) Cabin
CARRY-ON Sortie Module

NUMBER REQUIRED: One

DURATION: T.B.D. (1.0 hr assumed) HOURS

FUNCTIONAL REQUIREMENTS:

1) Manual Control
2) Deactivate Emergency and Normal PRESSURIZATION Systems
3) Manual Open/Close Vent Valve Sized to Allow Depressurization In 1.0 Hour or Less.
4) Independent Operation of Cabin and Sortie Module Pressurization Systems.

EQUIPMENT REQUIREMENTS

ITEM: #7 Repressurization

LOCATION(S): Cabin (Airlock Inherent)

FLIGHT REQUIREMENTS: ALL (SCAR): Cabin; CARRY-ON:

NUMBER REQUIRED: One

DURATION: 1.0 HOURS

FUNCTIONAL REQUIREMENTS:

1) Manual Control
2) Repressurization of Cabin in 1.0 Hours or Less
3) Stored Gas May Be the Emergency Flood Flow Reserve
4) Stored O_2 may not be the same reserve dedicated for contingnecy LSS suit loops

EQUIPMENT REQUIREMENTS

ITEM: #8 Jettison

LOCATION(S): Cargo Bay

FLIGHT REQUIREMENTS: ALL (SCAR) ____ CARRY-ON X

NUMBER REQUIRED: T.B.D. for each flight

DURATION: T.B.D. HOURS

FUNCTIONAL REQUIREMENTS:

1) Jettison any item which may prevent closure of cargo bay doors
   a) Cargo (e.g., kick stage)
   b) Deployed experiments
   c) Docked free flyers
   d) Docking mechanism when docked to modular space station
   e) Manipulator arms
   f) EVA can be used to Jettison or retract and stow
2) Jettison for rapid re-entry
   a) Cargo
   b) Deployed experiments
3) Jettison for EVA
   . Payload
   . Sortie module or provide emergency egress hatch for EVA transfer to rescue shuttle or contingency EVA for shuttle repair

EQUIPMENT REQUIREMENTS

ITEM: Item # 9 Leak Repair Kit

LOCATION(S): Cabin
Airlock

FLIGHT REQUIREMENTS:

ALL (SCAR)	In Cabin
CARRY-ON	Airlock

NUMBER REQUIRED: One

DURATION: N. A. HOURS

FUNCTIONAL REQUIREMENTS:

1) Portable to locate leak in cabin
2) Airlock unit requires spare hatch seal
3) Both cabin and airlock require:
   a) Leak location equipment (general area)
   b) Variable sizes of patches for irregularily shaped holes which may be in locations difficult to reach
   c) Leak detection equipment (specific point).

EQUIPMENT REQUIREMENTS

ITEM: Item # 10 EOP (24 Minute Emergency LSS)

LOCATION(S): Cabin
Sortie Module

FLIGHT REQUIREMENTS: ALL (SCAR) 2 units, cabin
CARRY-ON All personnel in sortie module

NUMBER REQUIRED: TBD for each flight

DURATION: 24 Minutes ~~HOURS~~

FUNCTIONAL REQUIREMENTS:

1) Overboard vent of 8.0 psia gas
2) Cooling of crewman by overboard vent flow (No LCG) 300 BTU thermal storage in man allowed
3) Metabolic rates
   a) 1200 BTU/Hr average rate
   b) 250 BTU/Hr suit heat leak

EQUIPMENT REQUIREMENTS

ITEM: Item # 11 EVLSS for Normal EVA

LOCATION(S): Cabin

FLIGHT REQUIREMENTS: ALL (SCAR) Two, in cabin
CARRY-ON None

NUMBER REQUIRED: 2

DURATION: 4 HOURS

FUNCTIONAL REQUIREMENTS:

1) Extravehicular life support system (EVLSS)
2) EOP
3) General Purpose tool kit
4) Portable light source
5) tethers
6) Two man activities for safety
7) Venting is allowed during an contingency EVA

EQUIPMENT REQUIREMENTS

ITEM: Item # 12 Purge or Flood Flow

LOCATION(S): Cabin
Airlock
Sortie Module
Docking Module

FLIGHT REQUIREMENTS: ALL (SCAR) SCAR
CARRY-ON

NUMBER REQUIRED: One

DURATION: 1.0 HOURS

FUNCTIONAL REQUIREMENTS:

1) Common system for cabin, airlock, docking module and sortie module.
2) Capability to deactivate system to depressurize any one or all four volumes.
3) Sufficient reserve gas for one cabin repressurization.
4) Flow rate for 1.0 hour more maximum credible leakage rate.
5) Reserve O_2 may not be used for contingency LSS.
6) Alert to crew when near exhaustion of the flood flow, 7 minutes prior to allow completion of suit donning, termination of repair activities. This may be a sensor activated by a specified pressure in the reserve gas storage.

EQUIPMENT REQUIREMENTS

ITEM: Item # 13 Flood Flow

LOCATION(S): Airlock

FLIGHT REQUIREMENTS: ALL (SCAR) CARRY-ON — Required only on flights with planned EVA/IVA

NUMBER REQUIRED: One

DURATION: 2 Minutes XHOURS

FUNCTIONAL REQUIREMENTS:

1) Repressurize airlock in 2 minutes at 6.0 psi/min. (450 lb/hr air) for contingency repressurization of airlock.
2) Rapid depressurization of airlock at 6.0 psi/min is required only on one man EVA/IVA's.
3) Cabin air at 14.7 psia may be used as source (reduces cabin to 13.2 psia); cabin repressurized slowly by emergency repress system.
4) Pressure equalization valve required to open airlock hatch to cabin may be employed as mechanism.
5) Manual control of repressurization rate. (Reduce rate or hold at pressure is adequate)
6) Remote deactivation of airlock pressurization system and flood flow

EQUIPMENT REQUIREMENTS

ITEM: Items # 14, #15, and # 25. Communications - #14 to Ground. #15 to Suited Man, #25 to Sortie.

LOCATION(S): Cabin
Commander/Pilot Station
Airlock
Sortie Module

FLIGHT REQUIREMENTS: ALL (SCAR) CARRY-ON — Central Station; airlock / Sortie Module

NUMBER REQUIRED: One connection for all personnel.
One central station with back-up modes.

DURATION: N.A. HOURS

FUNCTIONAL REQUIREMENTS:

1) Cabin central Communications at commander/pilots station either with or without pressure suits.
   a) To/from ground
   b) To/from rescue shuttle
   c) To/from personnel in pressure suits
      a) in cabin
      b) in airlock
      c) in sortie module
      d) EVA
2) Between personnel in pressure suits in cabin
3) RF and/or hardlines, TBD
4) Continuous communications contact EVA crew to each other and cabin. Scheduled status checks (10 minute intervals) to provide knowledge of a disabled crewman. R.F. blockage caution to alert cabin and EVA crew of a potential hazard.

EQUIPMENT REQUIREMENTS

ITEM: Item # 16 Thermally Protected Pressure Suits

LOCATION(S): Cabin
Sortie Module

FLIGHT REQUIREMENTS: ALL (SCAR) EVA
CARRY-ON Sortie, 1 each

NUMBER REQUIRED: 2 min.

DURATION: 30 min. to 4 HOURS

FUNCTIONAL REQUIREMENTS:

1) EVA suits (see previous discussions)
2) Passengers/crew in sortie module with thermal protection installed on suits prior to flight
3) When docking is possible only EVA
4) When docking is not possible all personnel require thermal protection for contingency EVA transfer. Carry up thermal protection by rescue shuttle.

EQUIPMENT REQUIREMENTS

ITEM: Item # 17 Rescue Umbilical

LOCATION(S): Cabin

FLIGHT REQUIREMENTS: ALL (SCAR) CARRY-ON -
With sortie module
No docking module

NUMBER REQUIRED: One

DURATION: Up to 3 HOURS

FUNCTIONAL REQUIREMENTS:

1) Length T.B.D. (approximately 10 to 30 feet)
2) One umbilical, for rescue crewman to assist a crewman making an ingress through the side hatch of the vehicle.
3) Umbilical consists
   a) tether
   b) Ventilation gas stream
4) Ventilation gas provides cooling and CO_2, trace contaminatant and humidity control.
5) Ventilation loop may be either open loop or closed loop.
6) If closed loop, it can be connected to suit loop cont. LSS if pressure drop is available.

EQUIPMENT REQUIREMENTS

ITEM: Item # 18 Manipulator as translator

LOCATION(s): Cabin

FLIGHT REQUIREMENTS: ALL (SCAR) All
CARRY-ON

NUMBER REQUIRED: One

DURATION: N.A. HOURS

FUNCTIONAL REQUIREMENTS:

1) Reach side hatch, locked in place with unpressurized cabin
2) Mobility aids on manipulator arm to allow a man to translate down arm when it is locked in place.
3) Tether attach points
4) Pick-up crewman and translate him to docking module hatch.
5) Jettison capability.

EQUIPMENT REQUIREMENTS

ITEM: ITEM # 19 Mobility Aids

LOCATION(S): Sortie Module
Cargo Bay

FLIGHT REQUIREMENTS: ALL (SCAR) Cargo Bay
CARRY-ON Sortie Modules

NUMBER REQUIRED: T B D

DURATION: N. A. HOURS

FUNCTIONAL REQUIREMENTS:

1) All aids should be in place before flight.
2) Possible to reduce number of fixed aids if an electroadhesive device can be used.
3) Burn-off hand holds for inspection tasks on bottom of shuttle
4) Aids on manipulator to translate along arm
5) Mobility aid on manipulator end-effector for man to hold when being translated by manipulator

EQUIPMENT REQUIREMENTS

ITEM: Items # 21, #22 and # 23 - Cabin Contingency LSS with Suit loops

LOCATION(S): Cabin

FLIGHT REQUIREMENTS: ALL (SCAR) Minimum crew size
CARRY-ON All personnel

NUMBER REQUIRED: 1 ea per person

DURATION: 3, 10, or 96 HOURS

FUNCTIONAL REQUIREMENTS:

1) Closed loop ventilation system (min. scar) for CO_2, trace contaminates, and heat rejection.
2) Umbilicals to allow limited mobility for all personnel (approximately 10 ft.)
3) Closed loop ventilation system.
4) Gas cooled crewman (no LCG loop in suit).
5) O_2 stored reserve can not be the same as emergency repressurization.
6) Composition of ventilation gas
   a) 8.0 psia pure O_2 for 3 hrs. or 10 hrs.
   b) 3.8 psi partial pressure O_2 Maximum for 96 hr, 8.0 psia total pressure (reduction in pressure to 3.8 is allowed after 10 hours)
7) Water and UTCA for 10 hr
8) Food, water, and waste management for suited operation for 96 hr

EQUIPMENT REQUIREMENTS

ITEM: Item # 24 1.7 Hour Cont. LSS for suited men

LOCATION(S): Airlock
Sortie Module

FLIGHT REQUIREMENTS:
ALL (SCAR): ---
CARRY-ON: Sortie module
Airlock only for planned EVA/IVA

NUMBER REQUIRED: 2 in airlock
1 per man in sortie module

DURATION: 1.7 HOURS

FUNCTIONAL REQUIREMENTS:

1) 1.7 hour duration assumes cabin and sortie module can be depressurized in 1.0 hour.
2) All life support functions with a gas cooled crewman. (No LCG loop in suit)
3) Short umbilical for limited mobility (less than 10 ft. if positioned near second egress hatch on sortie module).
4) No requirement for portability. This system must be in addition to cont. LSS in cabin.
5) If sortie module system is portable and used for cont. transfer to cabin, a 2.0 hour capacity is required. If it is also used during cabin repressurization a total of capacity of 3 hr. 15 minutes is required.

EQUIPMENT REQUIREMENTS

ITEM: Item # 26 Side Hatch Ingress Aid

LOCATION(S): Cabin

FLIGHT REQUIREMENTS: ALL (SCAR) -
CARRY-ON With sortie module
No docking module

NUMBER REQUIRED: One

DURATION: N. A. HOURS

FUNCTIONAL REQUIREMENTS:

1) Open and reseal side hatch
2) Platform and rail extending out of side hatch
3) Tether attach points
4) Rigid, but temporary installation
5) Rapid deployment and retraction
6) Foot restraints for one crewman to stand on ingress aid and assist a second one.

EQUIPMENT REQUIREMENTS

ITEM: Item # 27 - Computer Assist Decision Aid

LOCATION(S): Cabin

FLIGHT REQUIREMENTS: ALL (SCAR) ~~CARRY ON~~ Scar

NUMBER REQUIRED: One

DURATION: N.A. HOURS

FUNCTIONAL REQUIREMENTS:

1) Lights on systems status monitors indicating failed system(s).
2) Isolation logic to determine particular nature of failure
3) Visual Displays of:
   a) Time until an unsafe condition will occur under existing circumstances
   b) Time until a safe re-entry can be made to any landing site
   c) Time until a safe re-entry can be made to a prime landing site
4) Logic to evaluate different courses of action

EQUIPMENT REQUIREMENTS

ITEM: Item # 29 Repair Kits

LOCATION(s): Cabin

FLIGHT REQUIREMENTS: ALL (SCAR) T.B.D.
CARRY-ON

NUMBER REQUIRED: T.B.D.

DURATION: N.A. HOURS

FUNCTIONAL REQUIREMENTS:

1) Replacement parts for critical items necessary for re-entry
   a) TPS
   b) Items failing checkout
   c) Cargo bay doors manual closure
2) Other items as may be deemed desirable from failure modes and analysis study of shuttle
3) General purpose tool kit

EQUIPMENT REQUIREMENTS

ITEM: Item # 30 - Tether and Tether Attach Points

LOCATION(S): Cabin
Airlock
Sortie Module

FLIGHT REQUIREMENTS: ALL (SCAR) Scar
CARRY-ON Sortie Module

NUMBER REQUIRED: T.B.D.

DURATION: N.A. HOURS

FUNCTIONAL REQUIREMENTS:

1) Tethers in sortie module, one for every two men
2) Short tether to joint two men EVA
3) Tethers for two men EVA
4) Tether attach points
   a) Airlock and docking module
   b) Side hatch of cabin
   c) Sortie module
      . Interior near second hatch
      . Exterior
   d) Several locations in cargo bay
   e) Manipulator